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CONTENTS.

NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Acting Editor.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meterology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers, and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1915. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors" are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belén College, Habana.
The Government Meteorological Office of Jamaica,
The Meteorological Service of the Azores,
The Meteorological Office, London,
The Danish Meteorological Institute,
The Physical Central Observatory, Petrograd,
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JANUARY, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Feb. 23, 1916.]

SOLAR RADIATION.

Measurements by means of Marvin pyrheliometers of the intensity of direct solar radiation on a surface normal to the incident solar rays are made at Washington, D. C.,[1] Madison, Wis.,[2] Lincoln, Nebr.,[3] and Santa Fe, N. Mex.,[4] on days when the sky about the sun is free from clouds and from smoke of local origin.

Descriptions of stations.

At ***Washington, D. C.,*** the observations are made in the College of History building, American University, in a suburb 5½ miles northwest of the United States Capitol, 1½ miles northwest of the United States Naval Observatory, and 3 miles northwest of the central office of the Weather Bureau. There are no manufacturing establishments or other sources of smoke within a radius of about 3 miles, with the exception of private residences in which hard coal or wood is burned, and there are few of these within a radius of 1 mile. To the west and south, from which directions come most of the winds with clear skies, the country is thinly settled, and much of it is covered with forest trees. The university is therefore practically free from city influences, except with southeast or east winds, and then the sky is apt to be overcast. The latitude of the university is 38° 56′ N., the longitude is 77° 5′ W., and the elevation of the pyrheliometer above sea level is 418 feet (127 meters). Shelves outside second-story windows, one of which faces southeast and the other southwest, afford exposure for the pyrheliometer to the sun from sunrise to sunset.

At ***Madison, Wis.,*** the observations are made at the Weather Bureau office in North Hall, University of Wisconsin. This building is on a bluff in the upper campus, a short distance from the south shore of Lake Mendota. Most of the manufacturing plants of Madison are at a considerable distance to the east of the university, and in summer, with northwest winds, the atmosphere is quite free from smoke. In winter, however, there is apt to be considerable smokiness, especially with southerly winds. The most conspicuous smoke producers are the central heating plant of the university, about a third of a mile southwest of North Hall, and railroad yards about the same distance to the south. However, there are intervals on most cloudless days when the atmosphere in the direction of the sun is nearly free from smoke. The latitude of North Hall is 43° 5′ N., the longitude is 89° 23′ W., and the elevation of the pyrheliometer above sea level is 974 feet (297 meters). This station is the farthest north of the Weather Bureau pyrheliometer stations. Shelves outside fourth-story windows, one facing east and the other west, afford exposure for the pyrheliometer to the sun from soon after sunrise to nearly sunset, except for a short time near noon.

At ***Lincoln, Nebr.,*** the observations are made in the Experiment Station building, on the farm campus, State University farm. This is just outside the city limits of Lincoln, is 2½ miles northeast of the Weather Bureau office, and a like distance from the center of the business section of the city. There is some smoke from buildings on the farm campus, and on calm mornings the smoke cloud from the city extends out beyond this point. It usually disappears soon after sunrise, however, leaving the atmosphere practically free from smoke. A shelf outside a third-story south dormer window affords exposure for the pyrheliometer to the sun from sunrise to sunset. The latitude of the Experiment Station building is 40° 50′ N., the longitude is 96° 41′ W., and the altitude of the pyrheliometer above sea level is 1,225 feet (373 meters).

At ***Santa Fe, N. Mex.,*** the observations are made at the Weather Bureau office in the center of the city. There is considerable smoke from neighboring stacks, but the city is not enveloped in a smoke cloud. With a brisk wind, and especially a north wind, the air is sometimes practically free from smoke; but this same wind may bring with it considerable dust from the desert, particularly during afternoons in the fall months. The latitude of the Weather Bureau office at Santa Fe is 35° 41′ N., the longitude is 105° 57′ W., and the elevation of the pyrheliometer above sea level is 7,013 feet (2,138 meters). This station is therefore the farthest south and at the greatest elevation above sea level of any of the Weather Bureau pyrheliometric stations. A shelf outside a third-story east window affords the only exposure to the sun available for the pyrheliometer, and it is therefore possible to make radiation measurements during the morning hours only.

Observations.

All the Marvin pyrheliometers in use at stations have been compared from time to time with Smithsonian silver disk pyrheliometer No. 1, so as to bring the radiation measurements into conformity with the Smithsonian revised pyrheliometric scale.[5]

In this REVIEW, September, 1915, **43**:440, Table 4, are given values of the radiation intensity at zero air mass computed from pyrheliometric readings obtained at the different stations under specially favorable atmospheric conditions. The close agreement in these values is evidence of harmony in the indications of the several instruments employed.

Series of from five to ten readings one minute apart are taken as nearly as practicable at such intervals throughout a half-day period that they cover the times when the sun is at the zenith distances indicated by the headings in Table 1. Sometimes, however, a slight interpolation is necessary in order to obtain radiation intensities corresponding to these solar zenith distances. This is easily

[1] Summaries of earlier observations at Washington will be found in the Bulletin of the Mount Weather Observatory, 1910, 3:69-126; 1912, 5:182, Table 3; 1913, 5:302-303; MONTHLY WEATHER REVIEW, December, 1914, 42:648; 1915, March-December, inclusive.

[2] Summaries of earlier observations at Madison will be found in the Bulletin of the Mount Weather Observatory, 1912, 5:173-183, and in this number of the REVIEW, p. 8-12.

[3] Summaries of earlier observations at Lincoln will be found in this number of the REVIEW, p. 5-8.

[4] Summaries of earlier observations at Santa Fe will be found in the REVIEW for September and December, 1915, 43:439-443, and 590.

[5] *Abbot, C. G., & Aldrich, L. B.* Smithsonian pyrheliometry revised. (Smithsonian Misc. Collections, 1913, 60, No. 18.)

accomplished by plotting the logarithms of measured intensities against the corresponding air masses, or approximately the secants of the sun's zenith distance, as is illustrated in the REVIEW for September, 1915, **43**:441, figure 1. As is there shown, the observations for a half-day period at a given station plot in nearly a straight line, so that interpolations for $\frac{1}{10}$ or $\frac{2}{10}$ of an air mass can be made with accuracy.

Table 1 is a summary of all the observations that have been obtained at the different stations during the month. The monthly normals, from which the departures of the monthly means have been computed, are the arithmetical means of all the a. m. or p. m. observations corresponding to the respective air masses that have been obtained at each station in this month, including the current month, since the beginning of observations. As shown in this number of the REVIEW, page 5, the period covered by the observations at the State University farm, Lincoln, Nebr., is too short to give monthly means. The monthly means for Washington include the observations obtained at the central office of the Weather Bureau between 1905 and 1912, where the pyrheliometer was only 118 feet, or 36 meters above sea level, and the atmosphere contained more smoke than at the present exposure.

From Table 1 it is seen that at Washington, Madison, and Santa Fe the monthly mean radiation intensities are slightly above the normal. At Santa Fe the intensity of 1.62 gram-calories per minute per square centimeter measured on January 31 with the sun at zenith distance 60° is the highest intensity for air mass 2 yet measured at Santa Fe. The corresponding noon intensity is 1.66 calories, which is the highest noon intensity for January that has been measured at Santa Fe. The monthly maxima at Washington and Madison do not equal previous January maxima.

At Washington the percentage of polarization of skylight is measured with a Pickering polarimeter [6] which is exposed on the roof of the College of History building of the American University. The measurements are made at a point 90° from the sun and in his vertical, with the sun at zenith distance 60°. They are made only on days when the sky is practically free from clouds, and even then they are omitted if the ground is covered with snow. Measurements were obtained on five days during January, 1916. The maximum reading is 66 per cent and the mean is 64 per cent. The monthly maximum is therefore 2 per cent higher than the average maximum for January given in the Bulletin of the Mount Weather Observatory, **3**:114, Table 16.

In Table 2 are given vapor pressure measurements obtained at the regular 8 a. m. and 8 p. m. observations of the respective stations on days when solar radiation intensities were measured. Except at Lincoln there is a close relation between maximum radiation intensities and minimum vapor pressures. At Lincoln the observer reports—

The skies during January were not such as to allow many good observations. Days which can ordinarily be called cloudless were very often not of much value because of a film of atmospheric moisture which was at a stage midway between cloud and invisible moisture. Usually this mass did not rise above an altitude of 30°, but this was high enough to include the sun.

To this statement the official in charge adds—

January, 1916, was an unusual month as regards atmospheric moisture. As far as can be judged from the reports of cooperative observers, this was true over the entire State of Nebraska. An unusual number of halos, sun dogs, and tangential arcs were reported. On January 27, with the sun seemingly clear, a brilliant halo with tangential arcs was observed at Lincoln. The atmosphere must have been filled with ice crystals that did not present the appearance of clouds even to a close observer. This condition is more or less common in Nebraska each winter, but was more frequent than usual this last January. I have known these ice needles to fall all day, with the sun shining brilliantly all the time.

It will be noted from Table 1 that at Lincoln, on January 27, radiation intensities were nearly up to the average for the month. Apparently, therefore, the atmospheric layer containing the ice needles could not have been a deep one.

In the REVIEW for December, 1915, **43**:591, an apparently similar but intensified condition is described by Mr. John R. Weeks at Binghamton, N. Y.

TABLE 1.—*Solar radiation intensities during January, 1916.*

[Gram-calories per minute per square centimeter of normal surface.]

WASHINGTON, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Jan. 3	......	......	1.29	1.21	1.16	1.11	1.08	1.03	0.97	0.93
4	......	......	......	1.14	1.09	1.04	0.89	0.81	0.75	0.70
8	......	......	1.25	1.11	0.99	0.90	0.83	0.75	0.69	0.63
14	......	......	......	0.84	0,80	......	0.72	......	0.60	0.55
17	......	......	1.30	......	......	......	......	......	......	......
19	......	......	1.34	1.25	1.17	1.09	1.02	0.96	0.90	0.84
23	......	......	1.27	......	......	......	......	......	......	......
24	......	......	1.10	1.07	1.03	......	0.91	0.86	0.82	0.81
Monthly means	......	......	**1.26**	**1.10**	**1.04**	**1.04**	**0.91**	**0.88**	**0.79**	**0.74**
Departure from 9-year normal	......	......	**+0.03**	**+0.01**	**+0.02**	**+0.06**	**+0.00**	**+0.04**	**+0.02**	**+0.02**
P. M.										
Jan. 2	......	......	......	......	1.17	1.09	1.04	......	0.98	0.95
3	......	......	......	1.17	1.02	......	......	......	......	......
17	......	......	......	1.24	1.13	1.04	0.98	0.92	0.87	0.82
19	......	......	......	1.28	......	......	......	......	......	......
24	......	......	1.18	1.14	1.10	1.05	0.99	0.92	0.84	......
Monthly means	......	......	**(1.18)**	**1.21**	**1.10**	**1.06**	**1.00**	**(0.92)**	**0.90**	**(0.88)**
Departure from 9-year normal	......	......	......	**+0.09**	**+0.06**	**+0.11**	**+0.11**	**+0.09**	**+0.12**	**+0.14**

MADISON, WIS.

Date.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.										
Jan. 3	......	......	......	......	......	......	0.95	......	......	......
13	......	......	......	1.46	......	......	......	......	1.06	1.00
14	......	......	......	1.42	1.29	......	......	......	......	......
17	......	......	......	......	......	......	1.09	......	......	......
18	......	......	......	1.44	......	1.22	......	......	......	......
22	......	......	1.42	1.36	1.28	1.20	......	......	......	......
31	......	......	1.42	......	......	......	......	......	......	......
Monthly means	......	......	**(1.42)**	**1.42**	**(1.28)**	**(1.21)**	**(1.02)**	......	**(1.06)**	**(1.00)**
Departure from 6-year normal	......	......	**+0.03**	**+0.06**	**+0.00**	**+0.03**	**−0.06**	......	**+0.19**	**+0.03**
P. M.										
Jan. 5	......	......	......	......	1.36	1.27	1.16	1.00	......	......
7	......	......	......	1.15	1.13	1.02	0.87	......	......	......
13	......	......	......	1.50	......	......	......	......	......	......
18	......	......	......	1.44	1.40	1.32	......	......	......	......
22	......	......	......	1.37	1.30	1.26	1.19	......	......	......
31	......	......	......	1.38	1.31	......	......	......	......	......
Monthly means	......	......	......	**1.37**	**1.30**	**1.22**	**1.07**	**(1.00)**	......	......
Departure from 6-year normal	......	......	......	**+0.05**	**+0.05**	**+0.04**	**−0.05**	**−0.08**	......	......

[6] For a description of this polarimeter see *Pickering, Edward C.*, A new form of polarimeter. Proc., Amer. acad. arts and sci., Boston, (N. S.) 1885, **13**:294-302.

TABLE 1.—*Solar radiation intensities during January, 1916*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

LINCOLN, NEBR.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Jan. 1	......	......	......	1.31	1.26	1.22	1.18	1.13	1.07	......
3	......	......	......	1.39	1.33	1.23	1.15	1.08	......	......
17	......	......	......	......	......	1.29	1.20	1.12	......	......
22	......	......	......	......	1.12	0.98	0.91	0.75	......	......
27	......	......	......	1.32	1.22	1.20	......	......	......	......
29	......	......	1.46	1.42	1.38	......	......	......	......	......
Means	......	......	(1.46)	1.36	1.26	1.18	1.11	1.02	(1.07)	......
P. M.										
Jan. 3	......	......	1.46	1.37	1.30	1.24	1.16	1.09	......	......
5	......	......	1.49	1.43	1.37	1.32	1.27	1.21	1.17	......
7	......	......	1.31	1.27	1.25	1.24	1.14	......	......	......
13	......	......	......	......	......	1.26	1.20	1.14	1.09	......
16	......	......	1.56	1.39	1.25	1.11	......	......	......	......
18	......	......	1.42	......	......	......	......	......	......	......
21	......	......	......	......	......	......	0.88	0.70	......	......
27	......	......	1.45	1.35	1.29	1.25	1.21	1.16	1.11	......
29	......	......	1.49	......	......	......	......	......	......	......
31	......	......	1.50	1.42	1.35	1.28	1.22	1.16	1.11	1.05
Means	......	......	1.46	1.37	1.30	1.24	1.15	1.08	1.12	(1.05)

SANTA FE, N. MEX.

A. M.										
Jan. 3	......	......	1.59	1.51	1.36	......	1.31	......	......	......
4	......	......	1.51	1.44	1.37	1.31	1.17	1.13	1.10	......
5	......	......	1.52	1.40	1.35	1.32	1.21	1.09	......	......
8	......	......	1.56	......	......	......	......	......	1.20	......
12	......	......	1.59	1.51	......	......	1.26	1.16	1.05	......
31	......	......	1.62	1.56	1.46	......	1.30	......	......	......
Monthly means	......	......	1.56	1.48	1.38	(1.32)	1.25	1.13	1.12	......
Departure from 4-year normal	......	......	+0.08	+0.10	−0.01	±0.00	±0.00	±0.00	±0.00	......

TABLE 2.—*Vapor pressure at pyrheliometric stations during January, 1916, on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
	Mm.	*Mm.*		*Mm.*	*Mm.*		*Mm.*	*Mm.*		*Mm.*	*Mm.*
Jan. 2	7.87	3.45	Jan. 3	1.45	2.36	Jan. 1	5.36	3.00	Jan. 3	2.26	2.87
3	2.49	2.36	5	3.15	0.53	3	2.87	4.17	4	2.87	3.00
4	2.62	3.15	7	1.07	1.60	5	1.88	0.81	5	2.16	3.15
8	1.52	1.78	13	0.23	0.33	7	2.36	3.45	8	3.30	3.99
14	1.68	1.32	14	0.23	0.58	13	0.20	0.38	12	1.32	1.60
17	1.07	0.96	17	0.46	0.86	16	0.79	0.86	31	0.91	0.96
19	1.32	1.60	18	0.71	0.79	17	0.79	1.60			
23	2.87	3.63	22	3.45	2.16	18	1.24	2.06			
24	3.15	3.99	31	1.78	0.86	21	4.75	4.57			
						22	3.00	4.17			
						27	0.81	0.66			
						29	0.91	0.81			
						31	0.91	1.02			

TOTAL RADIATION ON A HORIZONTAL SURFACE.

Continuous records of the total radiation received on a horizontal surface from the sun and sky at Washington are obtained by means of Callendar pyrheliometer No. 13129. It is exposed on the capstone of a ventilating flue of the College of History building, American University, at a height of 451 feet, or 137 meters, above sea level. There is practically no obstruction between it and the sky in any direction down to the true horizon.

The records obtained from this instrument between November, 1914, and December, 1915, were reduced to heat units by the use of the factors determined at Mount Weather, Va.[7] In the REVIEW for March, 1915, (43:100) it was stated that there was evidence that these factors were too small. This statement was based upon the results of comparisons between the Callendar and the Marvin pyrheliometers, and it has been confirmed by comparisons that have been continued on all favorable occasions up to the present time.

For zenith distances of the sun less than 60° the comparisons give reduction factors that are in accord with those previously obtained. Between November 1, 1914, and June 20, 1915, with solar zenith distance in excess of 60° the comparisons give reduction factors that increase with the solar zenith distance. After June 20, taking advantage of the studies of Eric R. Miller[8] on the effect of internal reflection from spherical glass bulbs such as cover the Callendar receiver, the instrument at the American University has been oriented several times a day on clear days so as to keep the edges of the mica plates supporting the resistance grids approximately either at right angles to, or in the same vertical plane as, the incident solar rays. The result has been practically to eliminate variations in the reduction factor with variation in the sun's zenith distance. There still remains the effect of selective reflection from the bright grids,[9] so that the reduction factors that now apply are the same as those given in the REVIEW for August, 1914, 42:480, Table 8, for solar zenith distance 25.0°.

Table 3 gives the corrections that should be applied from November, 1914, to December, 1915, inclusive, to decade averages of the daily total solar and sky radiation as published in the REVIEW. These corrections are largest in the early winter, when the sun is almost continuously more than 60° from the zenith, and are smallest in summer. For reasons given above they are less after June 20, 1915, than before that date. These corrections for decade averages are too large for cloudy days and too small for clear days. As shown by the percentage corrections they are of little significance when applied to the total radiation on a single day, but the cumulative effect is to change a deficiency of 1882 gram-calories of radiation in the year 1915,[10] to an excess of 28 gram-calories. Or, it has changed a deficiency of 1.4 per cent to an excess of 0.02 per cent, which, practically, is no departure from the normal.

TABLE 3.—*Corrections to decade averages of daily totals of solar and sky radiation at Washington, D. C., between November, 1914, and December, 1915, inclusive.*

Month.	Decade.					
	First.		Second.		Third.	
	Gr.-cal.	*Per cent.*	*Gr.-cal.*	*Per cent.*	*Gr.-cal.*	*Per cent.*
1914.						
November	+ 9.7	+3.5	+8.9	+4.5	+7.7	+3.9
December	+ 0.9	+1.2	+9.5	+6.0	+7.2	+5.1
1915.						
January	+10.2	+5.4	+5.1	+4.5	+8.9	+6.1
February	+ 4.6	+2.9	+6.1	+2.6	+8.3	+2.7
March	+ 9.1	+2.6	+7.7	+2.0	+6.4	+1.5
April	+ 5.4	+1.2	+6.8	+1.4	+4.1	+0.9
May	+ 3.9	+0.8	+3.9	+1.0	+3.6	+0.8
June	+ 6.0	+1.3	+6.0	+1.1	+4.7	+0.7
July	+ 3.5	+0.6	+3.0	+0.7	+2.8	+0.5
August	+ 2.9	+0.6	+3.6	+0.8	+2.3	+0.6
September	+ 3.5	+0.9	+7.8	+1.8	+6.4	+1.5
October	+ 5.0	+1.9	+4.3	+1.9	+6.9	+2.1
November	+ 5.7	+2.2	+4.5	+2.2	+4.4	+2.3
December	+ 4.5	+2.8	+3.5	+2.4	+3.8	+2.5

[7] See this REVIEW for August 1914, 42:474–478, for a discussion of the method by which these factors were obtained.

[8] *Miller, E. R.*, Internal reflection as a source of error in the Callendar bolometric sunshine receiver. MONTHLY WEATHER REVIEW, 1914, 43:264–266.

[9] See this REVIEW for August, 1914, 42:476, 478, and 480.

[10] *See* the REVIEW for December, 1915, 43: 590, Table 2.

Commencing with January 1, 1916, new daily normals of the total solar and sky radiation have been employed. These have been determined in the same way as those previously used,[11] except that they are based exclusively on the data obtained at the central office of the Weather Bureau between July, 1909, and April, 1912, and at the American University between November 1, 1914, and the end of the current month.

In Table 4 are given the daily totals of radiation, the departures from the five-year daily normals determined as above, and the accumulated deficiency of radiation during the month. The latter shows an average deficiency of about 20 calories per day during the first two decades, but very nearly the normal amount of radiation during the third decade.

It will be seen from the sums of the daily totals and departures of radiation that the new normals are slightly lower than those published in the REVIEW for March, 1915, **43**: 106, Table 4.

TABLE 4.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during January, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.	Departures from normal.	Excess or deficiency since first of month.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*
Jan. 1	39	−121	−121
2	118	− 42	−163
3	224	63	−100
4	210	49	− 51
5	175	13	− 38
6	148	− 14	− 52
7	76	− 87	−139
8	233	69	− 70
9	150	− 14	− 84
10	58	−107	−191
11	30	−136	−327
12	25	−142	−469
13	101	− 67	−536
14	206	37	−499
15	204	34	−465
16	87	− 84	−549
17	235	62	−487
18	224	50	−437
19	286	110	−327
20	96	− 81	−408
Decade departure			−217
21	222	43	−365
22	74	−106	−471
23	260	78	−393
24	275	92	−301
25	212	27	−274
26	187	0	−274
27	202	13	−261
28	201	9	−252
29	142	− 52	−304
30	64	−133	−437
31	216	16	−421
Decade departure			− 13
Deficiency since first of year: Gram-calories			421
Deficiency since first of year: Per cent			7.8

SOLAR RADIATION MEASUREMENTS AT LINCOLN, NEBR., 1911-1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Feb. 19, 1916.]

The first solar radiation measurements at Lincoln, Nebr., were made by the writer in August, 1910, with Smithsonian silver-disk pyrheliometer No. 1. Regular observations were not commenced until November, 1911, when Marvin pyrheliometer No. 3, of the spiral ribbon type, was installed at the Weather Bureau office in the Brace Physical Laboratory, University of Nebraska. This laboratory is on the university campus, just north of the business section of Lincoln, and but a few blocks east of extensive railroad yards. In consequence, there is considerable smoke in the atmosphere, especially in winter, except when strong northwest winds prevail.

For the exposure of the pyrheliometer during observations, shelves were erected outside a south and a west third-story window of the laboratory. During the winter the sun could be observed from the south window at any hour of the day. During late afternoon hours in summer it could be observed from the west window, but both windows were in the shade during the early morning hours at this season.

The Marvin pyrheliometer has been compared from time to time with Smithsonian silver-disk pyrheliometer No. 1, and the results are summarized in Table 1. They do not indicate that the instrument has undergone any change, except that its coefficient of absorption was brought up to its original value by re-sooting on July 13, 1915.

Practically all the radiation measurements at the Weather Bureau office were made by Mr. G. A. Loveland, in charge of station, or by Mr. H. G. Carter, the first assistant. These measurements are summarized in Table 2 (City Station). On account of the small number of measurements obtained, seasonal means have been computed instead of monthly means. They are lower than are corresponding seasonal means for Madison, Wis., computed from the monthly means given in this number of the REVIEW, pages 9–12. This is probably because of the smokiness of the atmosphere at Lincoln.

The latitude of the Weather Bureau office at Lincoln is 40° 49′ N., its longitude is 96° 45′ W., and the elevation of the pyrheliometer above sea level was 1,190 feet, or 363 meters.

At the end of June, 1915, the Marvin pyrheliometer was transferred from the Weather Bureau office to the State Experiment Station building, on the farm campus at the State University Farm. This is just outside the city limits of Lincoln and about 2½ miles northeast of the Weather Bureau office. The latitude at this place is about 40° 50′ N., the longitude 96° 41′ W., and the elevation of the pyrheliometer above sea level 1,225 feet, or 373 meters. For details relative to this new exposure of the instrument (Farm Station) the reader is referred to this number of the REVIEW, page 2.

Practically all the pyrheliometric readings at the State University Farm have been made by Mr. Carl T. Hilmers, Assistant Observer, Weather Bureau. Those for the latter half of 1915 are summarized in Table 3. Comparison with Table 2 shows that these readings are markedly higher than those previously obtained during corresponding months at the Weather Bureau office, and except in August and September the monthly means are higher than those for Madison, above referred to. The highest readings obtained in each of the six months exceed the highest readings that have been obtained at Madison in the corresponding months in any year. It is therefore evident that radiation measurements obtained at the State University Farm at Lincoln, Nebr., *must be treated as a new series*, and not as a continuation of the series obtained at the Weather Bureau office.

[11] *See* the REVIEW for March, 1915, **43**: 101.

TABLE 1.—*Comparison of pyrheliometers at Lincoln, Nebr.*

Date.	Smithsonian No. 1.	Marvin No. 3.	Ratio, Marvin / Smithsonian.	Date.	Smithsonian No. 1.	Marvin No. 3.	Ratio, Marvin / Smithsonian.
1911.				1915.			
Aug. 21	1.277	1.269	0.994	July 9	1.267	1.260	0.993
22	1.328	1.311	0.987	10	1.371	1.341	0.978
Sept. 14	1.384	1.367	0.988	10	1.294	1.270	0.981
				10	1.183	1.158	0.979
1912.				11	1.317	1.306	0.992
Apr. 8	1.423	1.472	1.034	11	1.203	1.198	0.996
8	1.420	1.432	1.008	11	1.021	1.009	0.988
9	1.332	1.350	1.013	12	1.181	1.170	0.991
9	1.342	1.355	1.010	12	1.071	1.058	0.988
9	1.077	1.111	1.032	15	*1.054	*1.080	*1.025
12	1.299	1.308	1.007	15	1.207	1.212	1.004
				15	1.279	1.281	1.002
Oct. 12	1.030	1.054	1.023	15	1.315	1.300	0.989
12	1.174	1.204	1.025	15	1.252	1.232	0.984
12	1.253	1.238	0.998	15	1.116	1.112	0.996
12	1.169	1.187	1.015	15	1.019	1.017	0.998
				15	0.832	0.822	0.988
				17	1.287	1.275	0.991
				18	0.839	0.854	1.018
				20	1.025	1.064	1.038
				20	1.184	1.217	1.028
				20	1.291	1.323	1.025
				20	1.350	1.363	1.010
				20	1.295	1.284	0.992
				20	1.197	1.219	1.018

* Surface of Marvin instrument re-sooted on July 13.

TABLE 2.—*Solar radiation intensities at Lincoln, Nebr. (City Station).*

[Gram-calories per minute per square centimeter of normal surface.]

Dates.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
Air mass.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
1910.											
Aug. 16	1.31	1.16	1.04	0.92	0.82	0.73					
20		1.04									
21		1.15									
24	1.26										
1913.											
June 11	1.17										
12	1.20										
18	1.17										
23	1.20										
26	1.24										
27	1.29										
July 16	1.20	1.02									
17	1.23	0.91									
21	1.31										
Aug. 14		1.11									
27		1.03									
1914.											
June 9	1.38										
18	1.35										
23	1.28										
24	1.30										
July 2	1.37										
8	1.36										
Aug. 4	1.13	1.02									
5	1.28	1.05									
12	1.30	1.04									
25	1.35	1.07									
Means (summer)	**1.27**	**1.05**	**(1.04)**	**(0.92)**	**(0.82)**	**(0.73)**					
1911.											
Nov. 10				1.19	1.11	1.04					
12			1.50	1.42	1.34						
14			1.29	1.14							
14			1.16	1.12	1.09	0.94					
15			1.32	1.22			0.98				
15				1.19	1.11						
17				1.21							
23					0.96						
24			1.27					0.95			
29				1.22							
29				1.37							

TABLE 2.—*Solar radiation intensities at Lincoln, Nebr. (City Station)*—Continued.

[Gram-calories per square centimeter of normal surface.]

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
Air mass.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
1912.											
Oct. 12		1.27	1.13	1.00	0.91						
12		1.25	1.12	1.00	0.90	0.82	0.75	0.68	0.55		
15		1.16									
17		1.18									
18		1.22									
22		1.20									
25		1.15									
26		1.18									
29		1.23									
Nov. 13			1.15								
15			1.02								
18			1.14								
18			1.14								
19			1.00								
21			1.23	1.14	1.06	0.97			0.68		
21			1.28	1.00	0.78	0.65	0.59		0.49	0.45	
25				1.03							
29			1.06								
1913.											
Sept. 26		1.27									
26		1.38									
Oct. 22			1.18								
25				1.08							
1914.											
Sept. 1		1.03									
3		1.17	1.04								
18			0.97								
18		1.21	1.15	1.08							
24		1.37	1.27	1.08							
24			1.27	0.90							
30		1.13	0.99	0.87	0.80						
30		1.22	1.11	1.02							
Oct. 16		1.42	1.27								
16			1.28	1.19	1.12			0.89	0.82		
20					0.90						
27			1.37	1.22							
27			1.39	1.27	1.16	1.06	0.97		0.80		
29		1.44	1.33	1.22							
29			1.35	1.20	1.07	1.07	0.95		0.77		
Nov. 6			1.38	1.18	1.05						
6			1.37	1.26	1.14	1.00	0.94	0.90			
Means (fall)		**1.24**	**1.21**	**1.14**	**1.03**	**0.94**	**0.86**	**0.86**	**0.68**	**(0.45)**	
1911.											
Dec. 4				1.21							
4				1.21							
5				1.18		1.02					
27				1.32							
1912.											
Jan. 18			1.42								
Feb. 27		1.38									
Dec. 4				1.00							
6				0.92							
9				1.08							
10				1.10							
12				1.05							
12				1.06							
13				0.67							
19				1.00	0.88				0.59		
20				0.99		0.78		0.64	0.57		
23				1.09	1.00	0.87	0.81		0.70	0.65	
26				1.05							
27				0.92							
28				1.07							
31				1.14	0.96	0.87					
1913.											
Jan. 9				1.12							
15			1.02								
15			1.08								
Feb. 7			1.19								
7			1.24								
Dec. 10				1.20	1.09						
1914.											
Jan. 24						1.18					
26					0.97	0.75					
29			1.30	1.09		0.97	0.89		0.67	0.62	

TABLE 2.—*Solar radiation intensities at Lincoln, Nebr. (City Station)*—Continued.

[Gram-calories per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1914.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Feb. 7			1.26	1.13							
17			1.30		1.05						
24		1.42	1.28	1.05							
Means (winter)		(1.40)	**1.23**	**1.07**	**0.99**	**0.92**	(0.85)	(0.64)	**0.63**	(0.64)	
1912.											
Apr. 8		1.39									
8	1.49	1.42									
9	1.42	1.30									
9			1.18								
10			1.06	0.99	0.93	0.87	0.82	0.76	0.68		
11			1.06	0.95							
11		1.18	1.06								
12		1.25									
22	1.46	1.31	1.14								
24	1.25	1.18									
May 6	1.40	1.03	0.75								
8		1.38									
8	1.41	1.30	1.21								
15		1.33									
16		1.31									
21	1.32										
24	1.28	1.10	1.01	0.97							
1913.											
Mar. 6		1.24									
11		1.29	1.14	0.99	0.82						
21		1.26	1.10								
27		1.12	0.99								
28		1.05									
Apr. 11		1.18									
17		1.24	1.08	0.92							
26			1.07								
May 6		1.19									
23	1.26	1.00									
27	1.25	1.12									
1914.											
Mar. 5		1.40	1.28								
23		1.26	1.03								
23		1.26									
Apr. 8	1.53	1.39	1.22								
14		1.17	1.05								
May 13		1.26									
13		1.29									
14		1.12									
1915.											
Mar. 31		1.26									
Apr. 1		1.33									
2		1.39	1.25	1.12							
3		1.37	1.24	1.12	1.01	0.92					
5		1.33									
29	1.24	1.20									
May 11	1.34										
Means (spring)	**1.36**	**1.25**	**1.10**	**1.01**	**0.92**	(0.90)	(0.82)	(0.76)	(0.68)		

TABLE 3.—*Solar radiation intensities at Lincoln, Nebr. (State University farm).*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 3	1.36	1.22	1.12	1.06	0.99	0.93	0.77				
4		1.31	1.26	1.21	1.16						
5	1.37	1.27									
6	1.32	1.21	1.11	0.99	0.89						
7					1.02	0.91					
9	1.30										
15	1.33	1.20	1.08								
16	1.37										
17		1.24	1.15								
18						0.86	0.79				
20		1.34	1.27	1.18	1.11	1.04	0.98	0.92			
21	1.43	1.31	1.25	1.16	1.06	0.97	0.90	0.82			
22	1.38	1.27	1.17	1.08	1.02	0.96	0.88				
31				1.02							
Means	**1.36**	**1.26**	**1.18**	**1.10**	**1.04**	**0.94**	**0.86**	(0.87)			
P. M.											
July 5		1.24	1.13	1.05	0.97						
9		1.12									
10	1.38	1.28	1.19	1.10							
11	1.33	1.20	1.06	0.94	0.82						
12	1.34	1.18	1.09	1.00	0.89						
15		1.12	1.00	0.87	0.72						
17		1.14	0.97	0.87	0.80	0.72	0.66				
18			1.00								
20	1.42	1.32	1.22	1.16	1.09						
21			1.18	1.09	1.04	0.97	0.90	0.86			
23	1.38	1.16									
29	1.35	1.17	1.05								
30	1.35		1.08	1.00	0.93	0.86					
Means	**1.36**	**1.19**	**1.09**	**1.01**	**0.91**	**0.85**	(0.78)	(0.86)			
A. M.											
Aug. 5		1.22	1.11								
6							0.67	0.60			
10		0.68	0.58	0.48	0.41	0.35					
11		0.97	0.86	0.75	0.65	0.58	0.54	0.50			
12		1.06	0.93								
13			0.94	0.83	0.71	0.59					
14		1.08	0.93	0.81							
20					0.79	0.71					
21		0.97	0.90	0.80	0.66	0.59	0.53				
22		1.04	0.94	0.82	0.70		0.56	0.50	0.44		
24			0.89		0.63	0.56	0.50	0.41			
29		1.31	1.18	1.09	1.02	0.95	0.89	0.83			
30		1.33	1.23	1.13	1.07	0.98					
31			1.26	1.17	1.12	1.06	0.99				
Means		**1.07**	**0.98**	**0.88**	**0.78**	**0.71**	**0.67**	**0.57**	(0.44)		
P. M.											
Aug. 5		1.20	1.11	1.02	0.93	0.84	0.78	0.77			
6	1.31										
10	0.93						0.40				
12	1.16	0.99	0.84	0.71	0.62	0.55	0.49	0.44			
14		1.04	0.90	0.81							
16	1.24										
19	1.25				0.68	0.63	0.58	0.53	0.49		
20		1.19	1.08	0.98	0.91	0.82	0.75		0.62	0.57	
21	1.16	0.99									
22			1.09	0.97	0.86						
24	1.34	1.24	1.14	1.04	0.96	0.89	0.83		0.72	0.68	0.64
27						0.98					
29			1.23	1.15	1.08	1.01	0.95	0.90	0.84	0.79	
30	1.42	1.24	1.10	1.00	0.92	0.85	0.78	0.73	0.71	0.67	
31	1.43	1.32	1.18	1.08							
Means	**1.25**	**1.15**	**1.07**	**0.97**	**0.87**	**0.82**	**0.70**	**0.67**	**0.68**	**0.68**	(0.64)
A. M.											
Sept. 2		1.28	1.19	1.12	1.03	0.95					
4		0.94	0.85	0.73			0.46	0.40			
5		0.92	0.73	0.62	0.52	0.45	0.40	0.37			
7		1.26	1.12	1.00	0.89	0.79	0.70				
8					0.86	0.81	0.76	0.72	0.69		
17		1.21	1.07								
18		1.33	1.24								
21		1.44									
22			1.22	1.14	1.06	0.98	0.91	0.83			
Means		**1.20**	**1.06**	**0.92**	**0.87**	**0.80**	**0.65**	**0.58**	(0.69)		
P. M.											
Sept. 1		1.29	1.20	1.11	1.03	0.96	0.89	0.84	0.78		
2	1.39	1.26	1.05	1.00	0.92	0.84	0.75	0.67	0.63		
5	1.07										
7	1.34	1.17	1.06								
9	1.33	1.25	1.11	1.05	0.96	0.88	0.80	0.72	0.64		
13			1.01		0.75						

TABLE 3.—*Solar radiation intensities at Lincoln, Nebr. (State University farm)*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. P. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr. cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Sept. 16				0.97	0.87		0.76	0.72	0.68		
18	1.43	1.33	1.24	1.15	1.07	1.00	0.94	0.90	0.87		
19		1.10		0 84	0.75	0.67		0.59	0.54		
20		1.40	1.32	1.24							
21		1.40	1.28	1.17	1.08	0.99	0.92			0.78	
22		1.27	1.13	1.01	0.91	0.83	0.76	0.69	0.64		
27		1.26	1.15	1.05	0.97	0.91	0.84	0.77	0.71	0.67	
29		1.27	1.13								
Means	**1.31**	**1.27**	**1.15**	**1.06**	**0.93**	**0.83**	**0.83**	**0.74**	**0.69**	**(0.72)**	
A. M.											
Oct. 2		1.22	1.10								
5		1.44	1.32	1.21		1.02					
7					1.25	1.16	1.10	1.04			
8		1.51	1.44	1.37	1.30	1.23	1.17	1.11			
9			1.36	1.28	1.19	1.12	1.06	1.00			
10		1.37	1.32		1.13						
13		1.34	1.32	1.18		0.92	0.80	0.65			
17		1.35	1.27	1.19	1.13	1.07	1.00	0.89			
18			1.27	1.19		1.06			0.72		
21		1.29	1.21	1.14	1.06		0.93	0.88			
22		1.30	1.25	1.18	1.08	0.97	0.87	0.80			
23		1.37	1.30	1.22	1.16	1.09	1.02	0.94	0.87		
27		1.35									
29		1.43	1.35	1.27	1.13	1.00	0.94	0.87	0.79		
Means		**1.36**	**1.29**	**1.22**	**1.16**	**1.06**	**0.99**	**0.91**	**0.79**		
P. M.											
Oct. 2			1.11	1.03	0.94					0.64	0.60
3						1.06	1.01	0.97	0.92		
5		1.44	1.35	1.27	1.19	1.12	1.05	0.99	0.93	0.88	
8		1.51	1.42	1.34	1.28	1.21	1.16	1.11	1.06	1.02	
9		1.36	1.26								
13		1.34		1.15	1.08	1.01	0.96	0.90	0.82		
17			1.23								
21			1.21	1.13	1.06	0.99	0.92	0.85	0.81		
22			1.21	1.12	1.04	0.98	0.93	0.88	0.83		
26			1.22	1.03							
27			1.24	1.10							
29			1.29	1.20	1.14	1.07	1.00				
Means		**1.41**	**1.25**	**1.15**	**1.10**	**1.06**	**1.00**	**0.95**	**0.90**	**0.85**	**(0.60)**
A. M.											
Nov. 1						1.01	0.96	0.92	0.87		
8			1.39	1.35	1.26	1.19	1.12				
12			1.40	1.30	1.14		1.03				
14			1.54	1.45	1.35	1.24	1.11	1.01			
21				1.47	1.41	1.34	1.28	1.22			
26				1.43	1.33	1.24	1.16	1.09	1.02		
29				1.45	1.36	1.30	1.22	1.17	1.12		
Means			**1.44**	**1.41**	**1.31**	**1.22**	**1.13**	**1.08**	**1.00**		
P. M.											
Nov. 1			1.30	1.20	1.11	1.00	0.91	0.85	0.80		
11			1.42	1.36	1.23	1.18	1.13				
12			1.37	1.29	1.22	1.14					
19			1.43	1.36	1.30	1.25					
21			1.52	1.44	1.37	1.30	1.23	1.17	1.12	1.08	
26			1.50	1.29	1.16	1.07	1.01			0.91	0.89
28			1.49								
29			1.54	1.45	1.37	1.31	1.25	1.19	1.14	1.09	
Means			**1.45**	**1.34**	**1.25**	**1.18**	**1.11**	**1.07**	**1.02**	**1.03**	**(0.83)**
A. M.											
Dec. 4			1.30	1.23	1.14	1.09	1.02	0.92			
8			1.41		1.29	1.21					
13				1.36							
17			1.38	1.31	1.23	1.17	1.10	1.02			
20				1.42	1.34	1.24	1.13	0.99			
21				1.36	1.32	1.24	1.12				
28				1.50	1.41	1.22		1.17			
Means			**1.36**	**1.36**	**1.29**	**1.20**	**1.09**	**1.02**			
P. M.											
Dec. 3				1.30	1.28	1.17	1.11	1.06	1.00		
4				1.21	1.10	1.02	0.93			0.69	
8				1.35							
17					1.27	1.10					
21				1.35	1.29	1.24	1.19	1.14		1.04	0.96
28						1.38	1.32	1.26	1.20		
Means				**1.30**	**1.24**	**1.18**	**1.14**	**1.15**	**(1.10)**	**(0.86)**	**(0.96)**

SOLAR RADIATION MEASUREMENTS AT MADISON, WIS., 1913-1915.

By HERBERT H. KIMBALL, Professor of Meteorology, and ERIC R. MILLER, Local Forecaster.

[Dated: Washington, D. C., Feb. 15, 1916.]

The radiation measurements summarized in Table 3 below are in continuation of those for the period July, 1910, to June, 1912, inclusive, published in the Bulletin of the Mount Weather Observatory, 1912, **5** : 177-181. These latter are included on the monthly means of Table 3, which are the arithmetical means of all the A. M. or P. M. published measurements at the respective air masses for months of the same name.

The means here given are generally lower than those summarized in the Bulletin above referred to, p. 182, Table 2, and especially during the early months of the year. This is no doubt due in part to the marked depression in radiation intensities during the latter part of 1912 and most of 1913, following the eruption of Katmai volcano in Alaska in June, 1912.[1] Undoubtedly, however, the occasions are rare when such high values as those of the early months of 1911 and 1912 will be measured at Madison, since the atmosphere at that place is apt to be more or less smoky, especially during the winter months.

TABLE 1.—*Comparison of radiation intensities measured at different stations with exceptionally clear skies.*

[Gram-calories per minute per square centimeter of normal surface.]

Station.	Date.	Air mass.					
		1.5	2.0	2.5	3.0	3.5	4.0
		Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Madison, Wis.	Sept. 4, 1914	1.37	1.29	1.18	1.08		
Mount Weather, Va.	Sept. 28, 1914	1.48	1.40	1.32	1.26		
Madison, Wis.	Dec. 30, 1914			1.47	1.37	1.31	
Washington, D. C.	Dec. 26, 1914		1.51	1.42	1.32	1.24	
Madison, Wis.	Dec. 28, 1915			1.46	1.40	1.32	1.25
Lincoln, Nebr.	do			1.50		1.38	1.32
Santa Fe, N. Mex.	Dec. 24, 1915		1.59	1.53	1.43	1.35	1.30

On December 30, 1914, and December 28, 1915, the highest December radiation intensities of record at Madison were obtained, and on September 4, 1914, the highest September intensities. It is of interest to compare these with intensities at other stations at about the same time, as has been done in Table 1. The intensities measured at Mount Weather, Va., on September 28, 1914, are the highest September intensities ever measured at the station. Likewise, those for Washington on December 26, 1914, are the highest intensities for corresponding air masses measured at Washington in any month. This is also true of the measurements at Lincoln, Nebr., on December 28, 1915, while those obtained at Santa Fe on December 24, 1915, are the highest December radiation intensities yet measured at that station.

Marvin pyrheliometer No. 5, of the spiral-ribbon type, which became the station instrument at Madison on November 24, 1911, has been in continuous use since that date. It was recompared with Smithsonian silver-disk pyrheliometer No. 1 during March and April, 1912, and again in March, 1915. The results are given below in

[1] *See* Bulletin of the Mount Weather Observatory, 1914, **6** : 208, figure 1, for a graphic presentation of this depression.

Table 2, and do not indicate any change in the constants of the instrument.

TABLE 2.—*Comparison of pyrheliometers at Madison, Wis.*

Date.	Smithsonian No. 1.	Marvin No. 5.	Ratio: Marvin / Smithsonian
1911.	*Gr.-cal.*	*Gr.-cal.*	
Nov. 24	1.369	1.361	0.994
24	1.375	1.380	1.004
1912.			
Mar. 28	1.361	1.349	0.991
29	1.481	1.509	1.019
29	1.519	1.503	0.989
Apr. 5	1.251	1.243	0.995
5	1.282	1.258	0.981
5	1.016	1.002	0.986
1915.			
Mar. 26	1.449	1.486	1.026
26	1.500	1.529	1.019
27	1.383	1.425	1.030
*27	1.404	*1.417	1.009
30	1.394	1.391	0.998
30	1.383	1.372	0.992

*After resooting surface of the Marvin instrument.

For more detailed information relative to exposure of instruments and methods of observation the reader is referred to this number of the REVIEW, page 2.

TABLE 3.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	78.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M. 1913.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Jan. 8			1.20	1.13							
24			1.22	1.16	1.08	1.01	0.92	0.84	0.76		
28			1.22					0.83	0.77		
29			0.99								
1914.											
Jan. 12				1.31	1.24	1.16			0.91		
16									0.80		
22							0.92	0.86			
30				1.09				0.91			
1915.											
Jan. 18				1.38	1.28	1.20	1.10				
21				1.37		1.23	1.16				
29			1.43	1.35	1.22	1.11					
Means (1911–1915)			**1.33**	**1.34**	**1.28**	**1.18**	1.09	0.99	0.83		
P. M. 1913.											
Jan. 8				1.07	1.01	0.96					
24					0.97						
25				0.84	0.81						
28				1.13	1.06	0.99					
1914.											
Jan. 22				1.12							
1915.											
Jan. 29				1.36	1.31						
Means (1911–1915)				**1.31**	**1.23**	**1.15**					
A. M. 1913.											
Feb. 1			1.27					0.73	0.66		
3			1.21	1.10				0.68	0.60		
6			1.25	1.11							
7			1.26	1.16					0.73	0.66	
8				1.19	1.09	0.99					
11			1.24	1.13	1.03			0.75	0.68		
12			1.27	1.16	1.06			0.83	0.76		
19			0.61								
24		1.28	1.19	1.08	0.98						
28			1.16								

TABLE 3.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	78.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M. 1914.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Feb. 1			1.33								
5			1.21	1.07	0.96		0.88	0.86			
14			1.25	1.09	0.99	0.91					
16		1.47	1.37	1.27	1.17						
24			1.32	1.19		1.05	1.01				
1915.											
Feb. 8			1.48	1.37							
26		1.52	1.43	1.31							
27		1.45		1.26	1.18						
Means (1911–1915)		**1.50**	**1.35**	**1.29**	**1.20**	**1.19**	**1.14**	**0.97**	**0.95**		
P. M. 1913.											
Feb. 1				1.15		0.92					
3			1.27	1.16							
5			1.05								
7			1.21	1.11	1.00						
8					1.03			0.37			
11			1.28	1.14	1.04						
12			1.29	1.24	1.16	1.08					
24			1.18	1.07	0.97						
1914.											
Feb. 7				1.22	1.14	1.03					
14				1.25							
19			1.34	1.16	1.06						
1915.											
Feb. 6			1.38								
8			1.50								
17			1.09								
26			1.45	1.34	1.25	1.17	1.11				
27			1.35	1.26							
Means (1911–1915)			**1.36**	**1.29**	**1.18**	**1.14**					
A. M. 1913.											
Mar. 4		1.31	1.25	1.14							
6		1.31	1.16		0.93	0.81					
16							0.72				
22			1.19								
27		1.22	1.03								
29		1.07									
31		1.17	1.04	0.92	0.81						
1914.											
Mar. 9		1.45	1.30	1.21	1.13						
11		1.42	1.27								
16		1.39	1.24			0.98					
17					1.07						
20		1.44	1.32	1.19							
1915.											
Mar. 1		1.40	1.23	1.13				0.91	0.87		
8		1.48	1.36	1.27		1.11	1.04				
16		1.47	1.35	1.22							
23		1.43	1.35				1.06				
26		1.50	1.44				1.14	1.09			
27		1.43	1.35								
29							1.01				
30		1.41	1.32			1.09	1.00				
31			1.36	1.28		1.11	1.03				
Means (1911–1915)		**1.43**	**1.33**	**1.26**	**1.20**	**1.12**	**1.05**	**1.04**	**0.94**		
P. M. 1913.											
Mar. 4		1.32	1.25	1.14							
6			1.27	1.14							
11		1.24	1.12								
28		1.07									
29		1.02									
1914.											
Mar. 11		1.45	1.33								
14			1.20								
20		1.36									
1915.											
Mar. 16		1.48									
26		1.51		1.28	1.18						
30		1.46	1.36				0.97				
Means (1911–1915)		**1.39**	**1.34**	**1.26**	**1.21**		**1.08**				

TABLE 3.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	78.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M. 1913.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Apr. 1		1.33	1.22	1.12	1.02						
5			1.07	0.93							
13	1.26	1.20	1.11	1.01	0.92						
14	1.42	1.29	1.18	1.08							
15	1.36	1.25		0.99							
16	1.31	1.09	0.95	0.82							
18			0.98								
19	1.28	1.22	1.15	1.03	0.94						
26		1.09	0.95								
28	1.41	1.29	1.19	1.09							
29	1.36		1.04	0.92							
30	1.31	1.10	0.99								
1914.											
Apr. 8					1.08						
9	1.47	1.41	1.32		1.06						
1915.											
Apr. 29		1.31	1.21	1.13	1.04						
Means (1911-1915)	**1.35**	**1.31**	**1.19**	**1.11**	**1.09**						
P. M. 1913.											
Apr. 14		1.27	1.14								
16		1.02									
28		1.23	1.09								
29		1.19									
1914.											
Apr. 11		1.44	1.29								
Means (1911-1915)		**1.34**	**1.27**	**1.19**	**1.11**						
A. M. 1913.											
May 6	1.37	1.22	1.11								
7	1.32										
9	1.32										
10	1.23	1.17	1.03								
16	1.25										
1914.											
May 6	1.48	1.28		0.94							
9		1.29	1.18								
15	1.26										
18	1.18	1.05									
22		1.23	1.05								
25	1.19	1.06									
26	1.26	1.18									
30	1.42	1.28	1.19	1.11							
1915.											
May 10	1.15	1.03									
Means (1911-1915)	**1.31**	**1.19**	**1.10**	**0.99**							
P. M. 1913.											
May 9		1.14	0.91								
1914.											
May 6		1.29									
18		0.98	0.84								
Means (1911-1915)		**1.15**	**0.88**								
A. M. 1913.											
June 2			1.06								
4	1.21	1.07		0.83							
8		1.23	1.15								
10	1.26		1.03								
11	1.21	1.10									
12	1.25	1.10	0.96								
13	1.20		0.99								
27		1.06	0.93								
1914.											
June 15		1.25	1.11								
1915.											
June 17		1.21	1.17								
Means (1911-1915)	**1.24**	**1.17**	**1.07**								

TABLE 3.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	78.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
P. M. 1913.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
June 9		1.12									
10		1.14									
13		1.09									
27		1.08	0.99	0.91	0.83						
Means (1911-1915)		**1.11**									
A. M. 1912.											
July 5	1.04	0.94	0.87								
14		1.15	1.03								
16	1.13	1.01	0.87	0.75							
17	1.21	1.06	0.96								
25	1.16	1.07	0.97	0.87							
26	1.17	1.01	0.80	0.79							
1913.											
July 2			1.03								
20		1.10	0.97								
23	1.31										
24	1.37										
28			1.00								
1914.											
July 2	1.30	1.20	1.10	1.01							
17		1.25	1.17								
20	1.23	1.18	1.15								
29	1.39										
1915.											
July 3			1.11								
17		1.19	1.11	1.03							
21	1.23	1.13	1.04								
22	1.18	1.07	1.00								
Means (1910-1915)	**1.24**	**1.14**	**1.04**								
P. M. 1912.											
July 16		0.99	0.74								
1913.											
July 24			1.09								
28		1.11									
29		0.93	0.82								
30		0.95									
1914.											
July 21		1.08	0.91								
29		1.23									
Means (1910-1915)		**1.05**	**0.89**								
A. M. 1912.											
Aug 2			0.84		0.58						
1913.											
Aug. 1	1.30	1.18	1.09	1.01							
23		1.17	1.12	1.06							
25	1.16										
26	1.35	1.19		0.97							
27		1.14									
29			1.08								
1914.											
Aug. 3	1.21	0.97									
21	1.35	1.22									
1915.											
Aug. 18	1.33										
19	1.33										
Means (1910-1915)	**1.31**	**1.20**	**1.11**	**1.05**	**0.89**	**0.93**	**0.86**	**0.76**			
P. M. 1913.											
Aug. 1				1.01							
15		0.86	0.75								
25			0.88						0.45		
26		1.24	1.13								
28		1.23	1.08								
1914.											
Aug. 3		1.04									

TABLE 3.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	78.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
P. M. 1915.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Aug. 18		1.18			0.83						
19		1.25	1.12			0.85	0.75				
30		1.11									
Means (1910–1915)		**1.12**	**0.99**	**0.86**	**0.75**	**0.67**	**0.70**	**0.58**	**0.48**		
A. M. 1912.											
Sept. 26		1.03	0.89	0.77	0.69						
30			0.93		0.73						
1913.											
Sept. 4		1.01		0.84							
9		1.25	1.13	1.04							
12		1.28	1.24								
13		1.23			1.00						
26		1.23	1.20	1.03							
27		1.25					0.82				
1914.											
Sept. 2		1.27									
3		1.29			0.98						
4		1.37	1.29	1.18	1.08						
8					1.03						
21				0.85							
24		1.35	1.24			1.00					
1915.											
Sept. 21		1.29	1.22	1.17	1.13						
22		1.27	1.16		1.04	0.98					
Means (1910–1915)	**1.35**	**1.24**	**1.08**	**1.12**	**0.96**	**0.91**	**0.85**	**0.80**			
P. M. 1912.											
Sept. 26		1.01		0.65		0.42					
30		1.15	1.02								
1913.											
Sept. 4		0.98		0.73							
9		1.24	1.10								
10		1.05	0.95								
12		1.27		1.07							
26		1.22		1.09							
1914.											
Sept. 4		1.29									
18		1.12									
Means (1910–1915)		**1.19**	**1.08**	**0.98**	**0.95**	**0.72**	**0.76**	**0.74**			
A. M. 1912.											
Oct. 1		0.98	0.92	0.88	0.79	0.70	0.63	0.59			
4		1.20	1.09	0.95	0.88	0.82	0.74	0.70			
5		1.03	0.94	0.82	0.69	0.61	0.55	0.49			
7		1.18									
12		1.17									
13		0.99	0.88	0.79				0.54	0.46		
14			1.10		0.90	0.80		0.66	0.60		
15		1.21	1.06					0.70	0.65		
16			1.03				0.65	0.58	0.52		
17		1.15	0.98				0.57	0.49			
19		1.20	1.00				0.55	0.51	0.48	0.44	
23		1.35	1.23					0.81	0.75		
26		1.33	1.17	1.04	0.94			0.82	0.77		
1913.											
Oct. 1		0.98	0.87								
2		1.31		1.13							
3			1.19				0.80				
13		1.17			1.03			0.79			
18		1.30	1.18	1.07							
23			1.15	1.03	0.92						
24			1.21	1.08	0.97	0.87					
31			1.22	1.16		1.00	0.92	0.86	0.79		
1914.											
Oct. 27							1.04				
30			1.23				1.00				
31			1.18	1.08		0.95					
1915.											
Oct. 9					1.20			0.99			
21			1.21								
29				1.17							
Means (1910–1915)		**1.21**	**1.12**	**1.06**	**0.98**	**0.89**	**0.81**	**0.69**	**0.64**	**0.44**	

TABLE 3.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	78.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
P. M. 1912.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Oct. 4			1.08	0.95		0.77					
5			0.85								
7			1.04	0.92	0.82		0.67				
12			1.04								
14			1.07		0.81				0.51		
15									0.57	0.54	
16			1.07								
17			0.98					0.52	0.45		
18				0.88							
19			1.14	1.08	1.02						
23					0.91						
26			1.15	1.03	0.91						
29			1.01	0.94							
1913.											
Oct. 2				1.11							
3					0.88						
18			1.17								
24			1.18								
31					0.96						
1914.											
Oct. 30				1.22		1.06					
1915.											
Oct. 28			1.27								
Means (1910–1915)			**1.13**	**1.09**	**0.98**	**0.97**	**0.82**	**0.60**	**0.54**	**0.52**	
A. M. 1912.											
Nov. 2					0.60				0.55		
8				0.84			0.56				
14				0.98						0.48	
15			1.21	1.08	0.95						
18			1.10						0.68	0.61	
19								0.79	0.70		
21				1.27	1.07				0.81	0.76	
1913.											
Nov. 1			1.19	1.12	1.05			0.85			
4					1.12						
11				1.17	1.11			0.95			
13									0.77		
23			1.30	1.19	1.11			0.96			
24				1.27	1.22			1.11			
1914.											
Nov. 10			1.38	1.26							
21							1.02				
1915.											
Nov. 2					1.20				1.00		
8			1.30								
Means (1910–1915)			**1.30**	**1.20**	**1.12**	**1.21**	**1.03**	**0.97**	**0.80**	**0.45**	
P. M. 1912.											
Nov. 14				1.05	0.95						
15				1.10	1.00	0 91					
16						0.69		0.42			
21					1.07						
1913.											
Nov. 21								0.54			
1914.											
Nov. 10				1.29							
21				1.22							
Means (1910–1915)				**1.25**	**1.17**	**0.93**		**0.48**			
A. M. 1912.											
Dec. 9				1.12	1.03					0.72	
21				0.93	0.85	0.82			0.59	0.54	
22				0.92							
28				1.23	1.13	1.03				0.82	
1913.											
Dec. 4				1.16	1.05				0.78	0.72	
11				1.20		1.07		0.94	0.88		
17					1.12						
18					1.16			0.98			
1914.											
Dec. 11				1.29	1.17				0.94		
16				1.13							
21							1.14				
30				1.47	1.37						

TABLE 2.—*Solar radiation intensities at Madison, Wis., 1913 to 1915, inclusive*—Concluded.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M. 1915.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Dec. 2								1.08			
14				1.37							
28				1.46	1.39	1.32	1.25			0.99	
Means (1910-1915)				**1.25**	**1.17**	**1.11**	**1.15**	**1.04**	**0.85**	**0.68**	
P. M. 1912.											
Dec. 21					0.83	0.76	0.70				
22					0.83	0.76					
28					1.01						
1913.											
Dec. 11							1.01				
1914.											
Dec. 11					1.21	1.16					
19						1.12					
30						1.31					
1915.											
Dec. 13					1.29						
28					1.40	1.32	1.25				
Means (1910-1915)					**1.29**	**1.10**	**0.99**				

DURATION OF TWILIGHT.[1]

By twilight we mean the light experienced after sunset and before sunrise, and due to the reflection, diffraction, or diffusion of sunlight by the gas molecules, the water particles, and the dust of the atmosphere. The greater the distance of the sun below the horizon the higher and less dense are the atmospheric layers from which the light is received at the shaded surface of the earth. Observation has shown that under the most favorable atmospheric conditions the last trace of twilight disappears when the sun is from 16° to 18° below the horizon, indicating that above a height of 40 to 50 miles, or 60 to 80 kilometers, the air is too rare to reflect or diffuse an appreciable amount of sunlight.

The duration of twilight may be computed from the equation:

$$\cos h = \frac{\sin a - \sin \phi \sin\delta}{\cos \phi \cos \delta},$$

where a is the sun's altitude, considered minus below the horizon, δ is the solar declination or distance from the celestial equator, ϕ is the latitude of the place of observation, and h is the sun's hour angle from the meridian.

From the above equation it will be found that at the equator, at the time of the equinoxes, when the apparent path of the sun is along the prime vertical, it takes the sun 1 hour and 12 minutes to pass from the horizon to a point 18° below it, or vice versa. At the solstices, when the sun appears to describe a small circle about the earth's axis 23½° from the prime vertical, the time is 1 hour and 19 minutes. At latitude 49°, or the latitude of the northern boundary of the United States, where the sun's apparent path is inclined 49° to the plane of the prime vertical, at the equinoxes it takes 1 hour and 52 minutes for the sun to pass from the horizon to a point 18° below. At the time of the winter solstice it takes 2 hours and 3 minutes, while at the time of the summer solstice the sun does not reach 18° below the horizon. In fact, there is a period of 22 days, from June 10 to July 2, inclusive, during which on the clearest nights the twilight may continue from sunset to sunrise.

Soon after sunset on very clear evenings there frequently appears in the western sky a rosy or purple glow, in the form of an arc about 20° to 25° in diameter with the sun at its center. It disappears when the sun is about 6° below the horizon, indicating that it comes from atmospheric layers not more than 5 or 6 miles (8 to 10 kilometers) above the surface of the earth. It is in these layers that convective action principally occurs, and they are therefore the dusty layers, as well as the layers that contain most of the atmospheric moisture. The purple glow is attributed to the diffraction of light by the dust and water particles in these layers. During the day the same process produces the whitish glow that is seen about the sun in clear weather.

With the disappearance of this glow the intensity of twilight becomes insufficient for the continuance of outdoor occupations. Hence it is the duration of this portion of the twilight, which Europeans term *civil twilight*, that is of practical interest and especially to those engaged in pursuits having to do with transportation, or any other line of out-door work that requires artificial lighting after nightfall, either for illumination or for signal purposes.

The intensity of twilight is not entirely dependent upon the position of the sun, however. The state of the sky is a modifying factor. Clouds on the western horizon, or a hazy condition of the atmosphere that may be due to either dust or moisture, noticeably diminish the twilight intensity, and in the case of very dense clouds may almost completely obliterate it. It is believed, however, that Table 1, which gives the duration of civil twilight or the time required for the sun to pass from the horizon to a point 6° below or vice versa, will be found useful to Weather Bureau officials and others. But it must be understood that the duration as given applies to clear sky conditions only and is too long for cloudy or hazy conditions. Furthermore, high mountains and buildings, or any objects that obstruct the horizon near where the sun rises or sets, will diminish the duration of twilight. It will be noted that at the Equator civil twilight only varies in duration from 24 minutes at the equinoxes to 26 minutes at the solstices, while at latitude 48°, near the northern boundary of the United States, it varies in duration from 36 minutes at the equinoxes to 43 minutes at the winter solstice and 48 minutes at the summer solstice. At Cleveland the variation is from 32 minutes at the equinoxes to 37 minutes at the winter solstice and 39 minutes at the summer solstice.

Table 1 gives the difference between the time when the center of the sun reaches the true horizon and the time it reaches a point 6° below, or vice versa. Without material error, we may add this interval to the time of sunset given in the Weather Bureau Sunshine Tables, or subtract it from the time of sunrise, to obtain the time of ending of civil twilight in the evening or its beginning in the morning. The time thus determined will be that at which the upper limb of the sun is 6° lower than it was at the time it appeared to rise or set on a true horizon, assuming normal atmospheric refraction, and mean solar diameter.

[1] *Reprinted from the paper* "Daylight illumination and the intensity and duration of twilight," by H. H. Kimball, Ph. D., presented to the Pittsburgh Section of the Illuminating Engineering Society, Cleveland, Ohio, Feb. 18, 1916, and printed by the society in its Transactions.

TABLE 1.—*Duration of civil twilight.*

[Time required for the sun to pass from the horizon to a point 6° below or vice versa.]

North latitude.	0°	10°	20°	25°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°
Date.	Minutes of time.														
Jan. 1	26	26	28	29	31	31	32	33	34	35	37	38	40	42	45
11	26	26	28	29	30	31	32	33	34	35	36	38	39	41	44
21	26	26	27	28	30	30	31	32	33	34	35	37	38	40	43
Feb. 1	25	25	27	28	29	30	31	31	32	33	34	36	37	39	41
11	25	25	26	27	29	30	30	31	32	33	34	35	36	38	39
21	24	25	26	27	28	29	29	30	31	32	33	34	35	37	38
Mar. 1	24	25	26	27	28	28	29	30	31	32	33	34	35	36	38
11	24	24	26	27	28	28	29	30	30	31	32	34	35	36	37
21	24	24	26	27	28	28	29	30	30	31	32	33	35	36	38
Apr. 1	24	24	26	27	28	29	29	30	31	32	33	34	35	37	38
11	24	25	26	27	28	29	30	30	31	32	33	34	36	37	39
21	25	25	26	27	29	29	30	31	32	33	34	35	37	39	41
May 1	25	25	27	28	29	30	31	32	33	34	35	37	38	40	42
11	25	26	27	28	30	31	32	33	34	35	36	38	40	42	45
21	26	26	28	29	31	32	32	34	35	36	38	40	41	44	47
June 1	26	26	28	29	31	32	33	34	36	37	39	41	43	46	49
11	26	27	28	30	32	32	34	35	36	38	39	42	44	47	51
21	26	27	29	30	32	33	34	35	36	38	39	42	44	48	51
July 1	26	27	28	30	32	32	34	35	36	38	39	42	44	47	51
11	26	26	28	29	31	32	33	34	36	37	39	41	43	46	49
21	26	26	28	29	31	32	33	34	35	36	38	40	41	44	47
Aug. 1	25	26	27	28	30	31	32	33	34	35	36	38	40	42	45
11	25	25	27	28	29	30	31	32	33	34	35	37	38	40	42
21	25	25	26	27	29	29	30	31	32	33	34	35	37	39	41
Sept. 1	24	25	26	27	28	29	30	30	31	32	33	34	36	37	39
11	24	24	26	27	28	29	29	30	31	32	32	34	35	36	38
21	24	24	26	27	28	28	29	30	31	31	32	33	35	36	38
Oct. 1	24	24	26	27	28	28	29	30	30	31	32	34	35	36	37
11	24	25	26	27	28	28	29	30	31	32	33	34	35	36	38
21	24	25	26	27	28	29	29	30	31	32	33	34	35	37	38
Nov. 1	25	25	26	27	29	29	30	31	32	33	34	35	36	38	40
11	25	26	27	28	29	30	31	32	32	34	35	36	37	39	41
21	26	26	27	28	30	30	31	32	33	34	35	37	38	40	43
Dec. 1	26	26	28	29	30	31	32	33	34	35	36	38	40	41	44
11	26	26	28	29	31	31	32	33	34	35	37	38	40	42	45
21	26	27	28	29	31	31	33	33	34	36	37	39	40	43	45

In Table 2 are given photometric measurements of the intensity of twilight with the sun at different distances from the horizon, made by Mr. A. H. Thiessen at Salt Lake City, Utah. They are in accord with Mount Weather observations published in this REVIEW, December 1914, **42**:652, and show that on clear days with the sun 6° below the horizon the twilight is less than 1 per cent as intense as it is immediately after sunset; or, the illumination is approximately that produced by a standard candle at a distance of 3 feet, namely, 0.1 foot-candle, as compared with 10,000 foot-candles at noon on a bright summer day. And yet, on November 6, 1913, I was able to read a graduated circle to tenths of degrees until the sun was nearly 7° below the horizon, by holding the instrument normal to the bright western sky.

TABLE 2.—*Photometric measurements of daylight and twilight illumination at Salt Lake City, Utah, on a surface normal alternately to the zenith and the western horizon Dec. 15, 1914.*[1]

	Sun's—		Illumination.
	Hour angle.	Altitude.	
	H. m.	°	*Foot-candles*
Time of observed sunset	4 19	+2.8	
	4 22	+1.6	[2] 206
	4 25	+1.1	[3] 87
Computed time center of sun's disk was on true horizon, disregarding atmospheric refraction	4 37	±0.0	
	4 41	−0.6	[2] 42
	4 44	−1.1	[3] 20
	5 01	−4.0	[2] 1.6
	5 06	−4.8	[3] 0.4
	5 12	−5.2	[2] 0.12
	5 14	−6.2	[3] 0.07

[1] Dec. 15, 1914. Sunset clear behind Oquirrh Mountains, which are about 2,000 feet above the valley.
[2] Photometric surface normal to western horizon.
[3] Photometric surface normal to zenith.

A LUNAR HALO OF JULY 24, 1861.

Mr. William B. Frew, now 87 years of age and for many years our cooperative observer at Aledo, Ill., sends the accompanying old sketch, by himself, of an interesting case of lunar halos and paraselenæ which he observed in Mercer County, Ill., on July 24, 1861. He states:

The moon seemed to be giving full light. The circles were plainly marked and the "mocks" had about half the brilliancy of the moon. The paraselenæ were very bright, specially within the interior ring. The cross of light near the moon had about half the light of the moon and gradually decreased toward the circumference of the circle. The lower circle was too near the horizon to present another intersection below.

At about 11 o'clock the next day [July 25, 1861] parhelia of precisely the same form, though not quite so brilliant, were observed. I recollect the whole scene as one of the most beautiful I ever saw in that line.

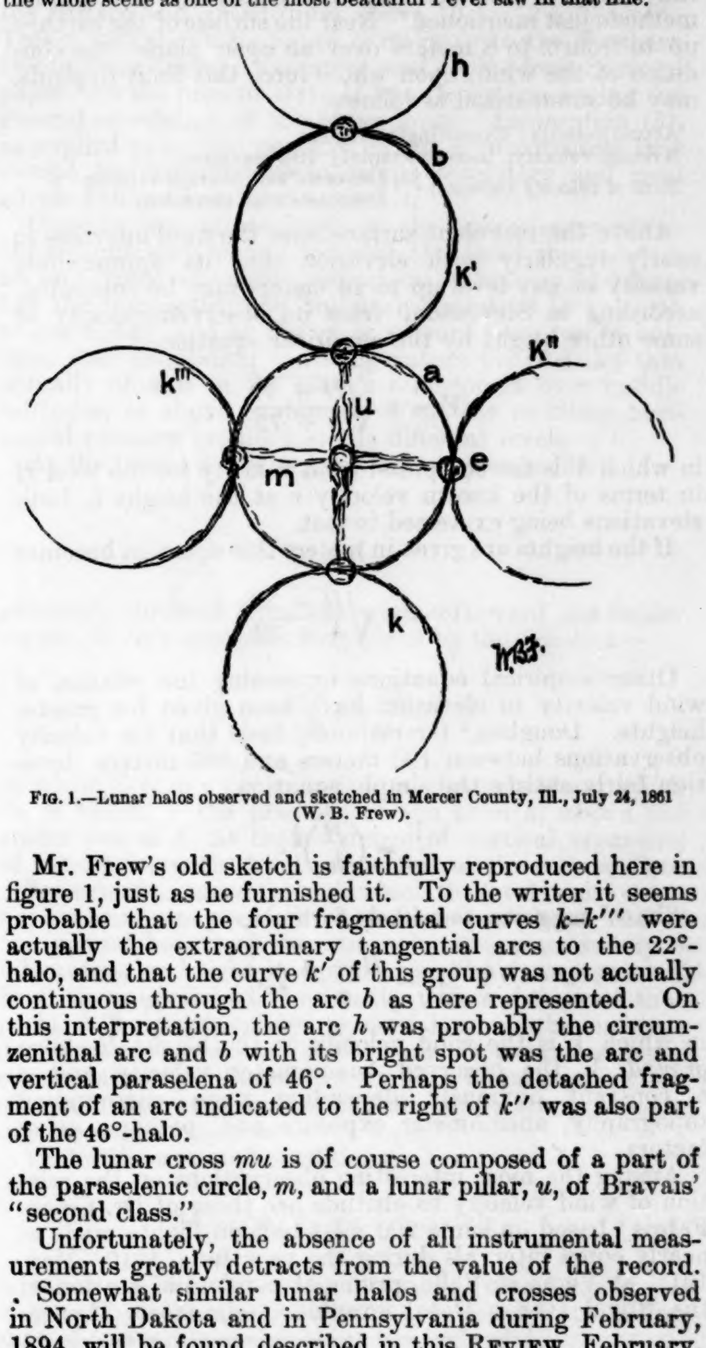

FIG. 1.—Lunar halos observed and sketched in Mercer County, Ill., July 24, 1861 (W. B. Frew).

Mr. Frew's old sketch is faithfully reproduced here in figure 1, just as he furnished it. To the writer it seems probable that the four fragmental curves k-k''' were actually the extraordinary tangential arcs to the 22°-halo, and that the curve k' of this group was not actually continuous through the arc b as here represented. On this interpretation, the arc h was probably the circumzenithal arc and b with its bright spot was the arc and vertical paraselena of 46°. Perhaps the detached fragment of an arc indicated to the right of k'' was also part of the 46°-halo.

The lunar cross *mu* is of course composed of a part of the paraselenic circle, m, and a lunar pillar, u, of Bravais' "second class."

Unfortunately, the absence of all instrumental measurements greatly detracts from the value of the record.

Somewhat similar lunar halos and crosses observed in North Dakota and in Pennsylvania during February, 1894, will be found described in this REVIEW, February, 1894, 22:76.—C. A., jr.

WIND VELOCITY AND ELEVATION.

By W. J. HUMPHREYS.

[Read before the Second Pan-American Scientific Congress, Washington, D. C., Section II B, Jan. 5, 1916.]

OBSERVATIONS.

Everyone knows that the wind increases with increase of elevation. Even casual observations of such objects as sails of ships, tops of trees, columns of smoke, or isolated clouds suffice to show qualitatively that wind velocity increases with height above the surface; while measurements made by triangulation on freely drifting clouds and balloons, or by anemometers on tethered kites, fully support the conclusions reached by the simpler methods just mentioned. Near the surface of the earth—up to from 2 to 8 meters over an open plane—the condition of the wind, upon whose force this limit depends, may be summarized as follows:

Actual velocity: Exceedingly irregular.
Average velocity: Increases rapidly with elevation.
Rate of velocity increase: {a, Increases with average velocity. b, Decreases with elevation.

Above the turbulent surface layer the wind increases so nearly regularly with elevation that its approximate velocity at any level up to 16 meters may be computed, according to Stevenson,[1] from its observed velocity at some other height by the empirical equation,

$$V = v\sqrt{\frac{H+72}{h+72}}$$

in which V is the computed wind velocity for the level H in terms of the known velocity v at the height h, both elevations being expressed in feet.

If the heights are given in meters this equation becomes

$$V = v\sqrt{\frac{H+22}{h+22}}.$$

Other empirical equations expressing the relation of wind velocity to elevation have been given for greater heights. Douglass,[2] for instance, finds that his velocity observations between 100 meters and 600 meters elevation fairly satisfy the simple equation

$$\frac{V}{v} = \left(\frac{H}{h}\right)^{\frac{1}{4}}.$$

Shaw [3] suggests, as a likely formula,

$$V = \frac{H+a}{a}V_0,$$

in which V is the wind velocity at the height H above *ground*, V_0 the observed anemometer velocity and a a constant obviously depending upon surrounding topography, anemometer exposure and, perhaps, other factors.

Among the most interesting observations on the relation of wind velocity to altitude are those of Dr. Cesare Fabris,[4] based on some 200 pilot balloon flights made at nearly equal intervals during the year June, 1910—May, 1911, at Vigna di Valle, principal aerological station of the Royal Italian Oceanographic Committee. The coordinates of this station are: Lat. 42° 04′ 41″ N.; long. 12° 12′ 43″ E.; altitude, 272.4 meters. It therefore is about 40 kilometers northwest of Rome.

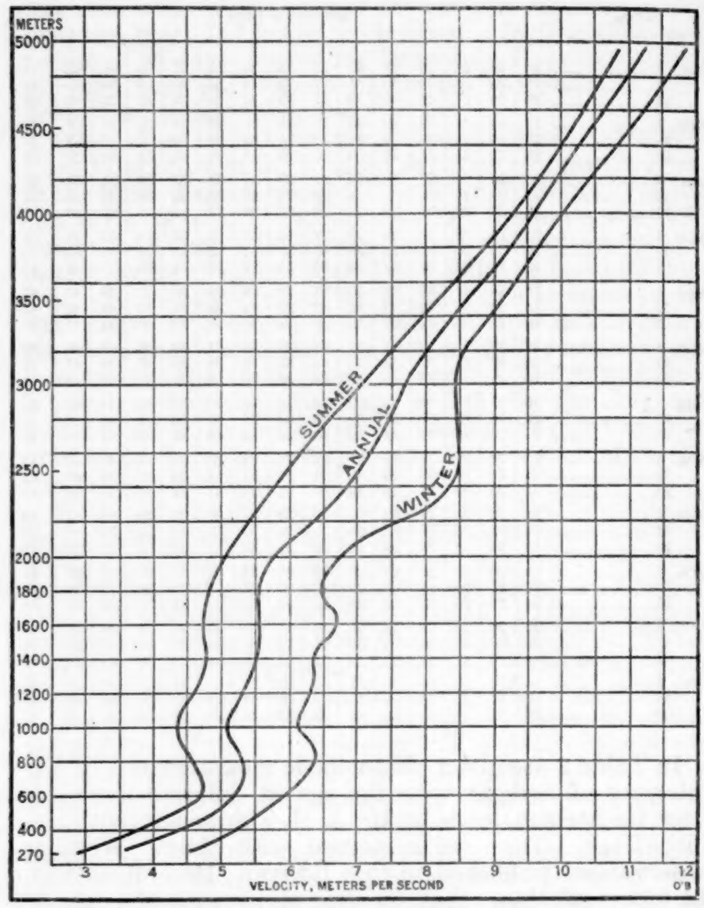

FIG. 1.—Relations of wind velocity to elevation, after Fabris.

The general results of all the observations are summed up in figure 1, which shows four distinct regions:

a. The region of rapid linear increase of velocity with increase of altitude; extending from the surface (272 meters above sea level), where the velocity is least, to an elevation of 600 to 700 meters. This obviously is the region in which the winds are affected by surface friction and the resulting turbulence. Clearly, too, the average number of eddies and their consequent effect on velocity must rapidly decrease with increase of elevation, substantially as indicated by the given velocity-altitude curves.

b. The region of velocity-decrease with increase of altitude; about 100 meters deep and coming immediately above *a*. This decrease probably is due to the mixing of two wind layers, an upper and a lower, moving in very different directions, and, therefore, merely a local and temporary rather than a universal phenomenon.

c. A region of irregular winds slowly increasing with increase of altitude; extending roughly from about 500 to 1,500 meters above the surface. These conditions are of very general occurrence between the levels given.[5] The irregularity probably is due to that frequent convectional mixing induced by insolation and, at night, by cloud evaporation.

d. A region of approximately constant increase of velocity with increase of elevation; beginning at about

[1] Jour., Scot. meteor. soc., 1880, 5: 348.
[2] Nature, 1885, 33: 593.
[3] Advisory Committee for Aeronautics, Reports and Memoranda, London, 1909, No. 9, p. 8.
[4] R. Comitato Talassografico Italiano, Memoria 8, pp. 37-46, 1912.
[5] *Berson*, Wissenschaftliche Luftfahrten, 1900, 3: 205.

1,500 meters above the surface and extending to at least the maximum height observed, 5,000 meters. The wind velocities of this region, being out of the reach both of friction and convectional disturbances, are determined by the prevailing horizontal pressure gradients.

Cloud and balloon observations show that increase of wind velocity with increase of altitude above 1,500 to 2,000 meters elevation, holds practically to the top of the troposphere where the velocity in middle latitudes may amount to as much as 90 meters per second (200 miles per hour), or even more.

At higher levels, that is in the stratosphere, the average velocity is decidedly less.

HORIZONTAL PRESSURE GRADIENT AND ELEVATION.

All these facts are well known, but there are no generally accepted and satisfactory discussions of the reasons why the average wind velocity at levels above the limit of appreciable surface influence, should go on increasing with increase of elevation up to the isothermal level and then decrease. Indeed data sufficient for a complete solution of this problem are not yet available, and it is only recently that enough facts have become known to indicate at all clearly the several links in the chain of cause and effect that determines the average atmospheric movements in middle and higher latitudes.

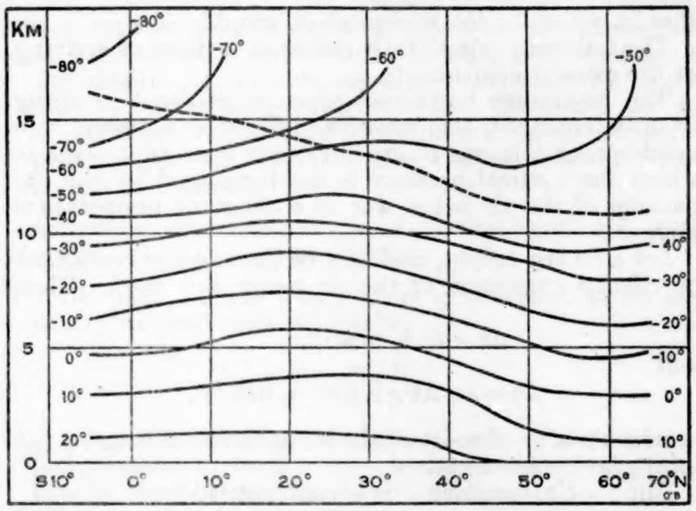

FIG. 2. Relation of temperature to altitude and latitude (N. Hem., Summer), after Süring.

Because of the actual distribution of insolation over the earth the temperature of the lower atmosphere, as shown by observation, is warmest, on the average, in equatorial regions and coldest beyond the polar circles, with intermediate values over middle latitudes. Hence, since the temperature of the air above the earth depends mainly upon convection and radiation from below, it follows that the latitude distribution of temperature in the upper air must be substantially the same as that at the surface, that is, warmest within the tropics and coldest in the polar regions, with intermediate values between. And this, indeed, according to kite and balloon records, does apply at each level up to 10 to 12 kilometers, or to fully three-fourths of the air mass. At much higher levels, 15 to 20 kilometers, for reasons that need not be discussed here, the rare atmosphere is coldest over equatorial regions and warmest over high latitudes. This inverse condition, however, does not apply to the winter and summer atmospheres of the same place, nor to those of neighboring places on approximately the same latitude.

As a crude first approximation to conditions as they actually exist, assume (1) that the temperature distribution is the same along all meridians, (2) that the temperature change from one latitude to another is the same for all levels, and (3) that sea-level pressure is the same at all latitudes. Assumption (1) approximates the conditions over much the greater portion of the Southern Hemisphere, but, on account of the irregular distribution of land and sea, has to be modified for any detailed study of the winds of the Northern Hemisphere. Assumption (2) conforms roughly to average conditions between the thermal equator and latitude 50°–60°, except near the surface and at altitudes above 10 to 12 kilometers. This is well shown by figure 2, referring to the Northern Hemisphere during its summer, and copied from Süring's paper [6] on the present state of knowledge concerning the general circulation of the atmosphere. Assumption (3), as applied to normal pressure, is also approximately true except for restricted areas, whose secondary and local effects will not here be discussed.

Consider an atmosphere of the same composition throughout and having initially the same temperature at any given elevation resting on a horizontal plane. Let the temperature be uniformly increased from north to south, say, and by the same amount from top to bottom, thus simulating the temperature distribution that actually obtains in the earth's atmosphere over middle latitudes, as above explained. Find the resulting horizontal pressure gradient at the different levels.

At the height h the horizontal pressure gradient,

$$\frac{dp}{dn},$$

obviously directed from the warmer toward the colder region, is very approximately given by the equation—

$$-\frac{dp}{dn} = p\frac{\Delta h}{HL},$$

in which L is any given horizontal distance along which dn is taken, p the pressure at the level h, above the colder end of L, Δh the difference of vertical expansion of the air below the level in question at the ends of L, or difference of distance through which the level whose original pressure was p was lifted at these two places, and H the virtual height of the atmosphere, approximately 8 kilometers, or height it would have above any point if from there up it had the density which obtains at that point. The negative sign is used because the pressure decreases as n, measured from a warmer toward a colder region, increases. For simplicity let L be in the direction of maximum rate of horizontal temperature change, north-south, in this case.

Under the assumed conditions,

$$\Delta h = a^{\frac{1}{2}}\Delta T h, \text{ approximately,}$$

in which a is the average coefficient of volume expansion of the atmosphere below the level h, and ΔT the difference of temperature change at the ends of L.

[6] Zeitschrift der Gesell. für Erdkunde, Berlin, 1913, 600.

At any two levels, then, h and h', the horizontal pressure gradients in the same direction are given approximately by the respective equations,

$$-\frac{dp}{dn}=\frac{pa^{1/3}\Delta Th}{HL},$$

and

$$-\frac{dp'}{dn}=\frac{p'a'^{1/3}\Delta T'h'}{H'L}.$$

But L may be taken the same in both equations, while a, H, and ΔT generally are not greatly different respectively from a', H', and $\Delta T'$. In reality,

$$\frac{H}{H'}=\frac{T}{T'},$$

and a' is slightly greater than a when T' is less than T. But in this case it appears from observations that actually $\Delta T'$ is slightly less than ΔT, so that

$$\frac{\frac{dp}{dn}}{\frac{dp'}{dn}}=\frac{ph}{p'h'}, \text{ approximately.}$$

Again, from the 5 to the 10 kilometer level, and even to some distance below the former and above the latter,

$$\frac{p}{p'}=\frac{h'}{h}, \text{ roughly.}$$

Hence, commonly,

$$\frac{\frac{dp}{dn}}{\frac{dp'}{dn}}=\frac{h'h}{hh'}=1, \text{ approximately.}$$

That is, through these levels or from below 5 kilometers to above 10 kilometers the horizontal pressure gradient established by the temperature difference between adjacent regions of air is roughly constant. This conclusion is fully supported by observations as shown by figure 3, referring to the Northern Hemisphere during its summer, and also copied from Süring's paper.[7]

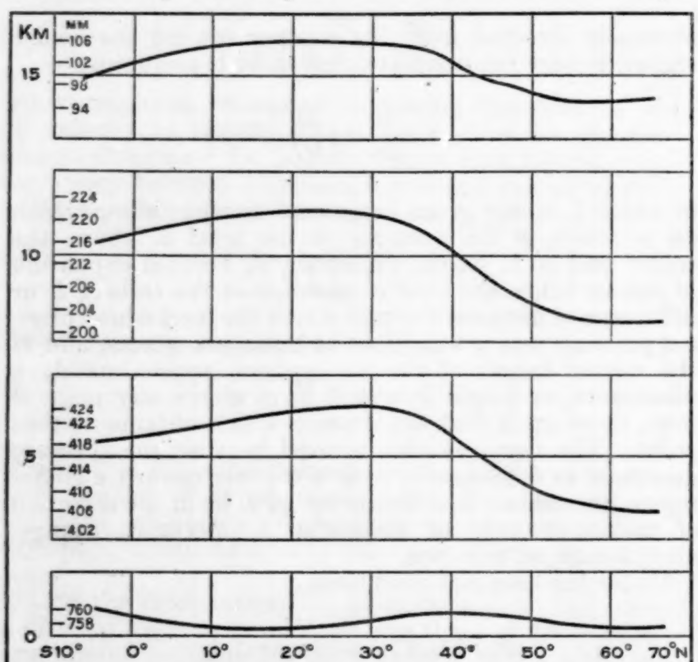

FIG. 3.—Relation of pressure gradient to altitude and latitude (N. Hem., summer), after Süring.

[7] Süring, op. cit.

LEVEL OF MAXIMUM HORIZONTAL PRESSURE GRADIENT.

The approximate level of the maximum horizontal gradient may be found as follows:

As just explained, in the equation

$$-\frac{dp}{dn}=\frac{pa^{1/3}\Delta Th}{HL},$$

the factor

$$\frac{a^{1/3}\Delta T}{HL}$$

is roughly constant. Writing G for the gradient and K for the "constant," the equation takes the form,

$$G=Kph.$$

Hence G has a maximum value when

$$p\,dh=-h\,dp.$$

But,

$$-dp=p\frac{dh}{H}.$$

Hence the pressure gradient is steepest when

$$p\,dh=\frac{h}{H}p\,dh,$$

that is, when $h=H=8$ kilometers, roughly.

The following is a slightly different method of arriving at the same conclusion:

The maximum horizontal pressure gradient resulting from a constant temperature difference between two neighboring columns of air obviously is at that level at which the vertical pressure is most changed by the expansion of the air below due to a constant temperature increase.

Let h be any height, and let a be the average coefficient of volume expansion of the air below this level. Then

$$\Delta h=a^{1/3}\,h, \text{ nearly,}$$

and

$$\Delta p=\rho\,g\,\Delta h=\rho\,g\,a^{1/3}\,h, \text{ nearly,}$$

in which ρ is the density of the air at the level h, and g the local gravity acceleration.

But $\rho=Cp$, in which C is a constant, and

$$\Delta p=p\,C\,g\,a^{1/3}\,h=K\,p\,h,$$

say, in which K may be regarded as a constant.

Hence, as before, Δp has its maximum value when

$$p\,dh=-h\,dp=\frac{h}{H}p\,dh.$$

That is, the horizontal gradient is steepest when $h=H$. But, as is well known, $H=8$ kilometers, approximately. Hence the horizontal pressure gradient resulting from a temperature distribution substantially that which actually obtains in the atmosphere, is greatest at a height of about 8 kilometers.

CONSTANCY OF MASS FLOW—EGNELL'S LAW.

At a distance above the surface of the earth sufficiently great to avoid appreciable retardation due to friction and turbulence, that is, at elevations greater than 2 kilometers (usually less), the wind obviously must blow in such direction and with such velocity that there is an approxi-

mate equation between the pressure gradient on the one hand and the combined centrifugal force and deflection force due to rotation on the other. Hence, at these levels, if dp/dn is the maximum horizontal pressure gradient,

$$\frac{dp}{dn} = -\rho V\left(2\,\omega \sin\phi + \frac{V}{R}\tan\phi\right), \text{ approximately,}$$

in which ρ is the density of the air at the level under consideration, V the wind velocity, ω the angular velocity of rotation of the earth, ϕ the latitude, and R the radius of the earth.

A little calculation shows that the second term in the parentheses is always small, except in very high latitudes, in comparison with the first. Thus for a west wind moving 22.4 meters per second (50 mis./hr.), at latitude 45°, the first term is about 30 times greater than the second. Hence, under these conditions,

$$\frac{dp}{dn} = -2\,\rho V\omega \sin\phi, \text{ approximately.}$$

But, as just explained, the horizontal pressure gradient, dp/dn, is roughly constant between 5 and 10 kilometers elevation. Hence at any given latitude, ρV, the mass flow, or mass of air crossing unit normal area per unit time, tends to remain constant with change of altitude from 4 or 5 kilometers above sea level up to the isothermal region. In other words, through this region, ρV, at altitude h is equal to $\rho' V'$ at altitude h', nearly. This relation between the density and velocity of the atmosphere at different levels is known as Egnell's law,[8] determined empirically by himself, as also previously by H. H. Clayton,[9] from cloud observations. Obviously ρV has a maximum value at that level at which the horizontal pressure gradient is a maximum, that is, at about 8 kilometers above sea level.

RELATION OF VELOCITY TO ALTITUDE ABOVE 5 KILOMETERS.

Obviously, if the temperature is constant, as for simplicity we may assume it to be,

$$\frac{\rho}{\rho'} = \frac{p}{p'}.$$

But, as already seen, under this condition of constant temperature, through a considerable range of altitude—that is, from below 5 to above 10 kilometers—

$$\frac{p}{p'} = \frac{h'}{h}, \text{ roughly.}$$

Hence,

$$\frac{\rho}{\rho'} = \frac{h'}{h}, \text{ roughly.}$$

But, as explained above

$$\rho V = \rho' V', \text{ nearly,}$$

therefore,

$$\frac{V}{V'} = \frac{h}{h'}, \text{ approximately,}$$

or the velocity of the wind through the levels in question is roughly proportional to the altitude.

Above the isothermal level over the regions between the thermal equator and latitude 50° or 60° the horizontal temperature gradient decreases, and presently even reverses, with increase of elevation, as shown by figure 2, and therefore the corresponding pressure gradient also decreases as shown by figure 3. Hence the mass flow, ρV, likewise decreases with elevation above this critical level. Further, the decrease of the horizontal pressure gradient, and, consequently, of ρV, with altitude in the stratosphere appears usually to be more rapid than that of the density alone, from which it follows that the wind velocity generally must have its maximum value at or below the isothermal level.

[8] Comptes rendus, 1903, 136:360.

[9] *Clayton* in Amer. met'l. jour., Boston, August 1893, 10:177.

SOME RESEARCHES IN THE FAR EASTERN SEASONAL CORRELATIONS.

(FIRST NOTE.)

By T. OKADA.

[*Reprinted from* Journal of the Meteorological Society of Japan, December, 1915, 34, No. 12.]

I.

1. *Introduction.*—It is a well-known fact that for the Far East the great pressure maximum over Siberia and the deep barometric minimum to the south of the Aleutian Islands are the prominent centers of action of the atmosphere in winter, while the great Pacific anticyclone and the continental low area are their summer counterparts. The weather anomaly of the Far East, especially of this country [Japan] is closely and causally related to the occasional change in the positions and intensities of these atmospheric centers.

In 1910 the author published a short paper containing a number of examples of simultaneous correlations in air temperature and rainfall at some places in the Far East. The present note will give a few examples of the remarkable interdependence existing between the pulsations of the Siberian anticyclonic system in winter and the air temperature anomaly of the east coast of Japan in the following summer. The investigation of this correlation may be of some interest for the solution of the fascinating problem of the climatic forecast which aims at predicting the general character of a coming season months in advance.

2. *Method and data.*—As an index of the intensity of the center of action the absolute value of the barometric pressure at a locality situated in the center is not a suitable one. The true measure of the intensity is the barometric gradient. The barometric readings at the Irkutsk Observatory, lying in the heart of the atmospheric center, may be of great service in estimating the intensity of this center. But the great altitude of Irkutsk requires a large correction to be added to reduce its barometric readings to sea level and this greatly reduces the value of those readings as data for the present investigation. In calculating the barometric gradient the most proper material is the pressure data of the meteorological stations lying near sea level. I have therefore used the results of observations taken at the observatories at Zikawei, Nafa, and Izugahara. The geographical coordinates of these observatories are:

Observatory.	Longitude.	Latitude.	Altitude.	Established.
			Meters.	
Zikawei	119° 6′ E.	31° 12′ N.	7.0	1873
Nafa	127° 4′ E.	26° 13′ N.	10.4	1890
Izugahara	129° 16′ E.	34° 12′ N.	9.2	1886

First were computed the differences between the sea-level pressures at Zikawei and Nafa, and those at Zikawei and Izugahara. Since Nafa and Izugahara are equally distant from Zikawei these differences of pressure may be considered as the components of the required pressure gradient. From these components we have computed

the resultant gradient at Zikawei by the graphical method.[1] The calculated gradients are not expressed in the customary unit, simply because it is unnecessary to do so for the present investigation.

Table 1 gives the component gradients and their resultant for the mean pressure at Zikawei for March.

TABLE 1.—*Barometric gradient at Zikawei [2] for March.*

Year.	Pressure at Zikawei (760+).	Pressure differences. Zikawei—Nafa.	Pressure differences. Zikawei—Izugahara.	Barometric gradient.	Azimuth.
	mm.	*mm.*	*mm.*	°	*N.—°E.*
1891	5.9	3.3	1.8	3.35	121
1892	6.7	5.0	1.7	5.00	134
1893	5.4	2.5	1.0	2.50	130
1894	5.7	3.2	2.4	3.45	109
1895	5.1	1.9	1.1	1.95	120
1896	7.3	4.0	1.1	4.05	138
1897	5.7	3.2	−0.6	3.75	162
1898	6.0	4.3	0.9	4.35	141
1899	6.0	2.3	2.1	2.65	100
1900	5.9	2.5	1.9	2.70	109
1901	7.6	2.1	1.4	2.20	114
1902	3.7	0.6	0.0	0.75	153
1903	3.9	2.2	0.3	2.30	145
1904	5.2	3.8	1.2	3.80	135
1905	6.7	3.7	1.0	3.75	137
1906	6.5	2.3	2.7	3.05	91
1907	6.0	2.9	1.9	3.05	115
1908	7.0	3.2	1.8	3.30	120
1909	6.7	3.7	1.2	3.75	134
1910	5.3	2.5	1.1	2.55	127

Table 2 gives the component gradients and their resultant for the mean pressure at Zikawei for the three months, January to March:

TABLE 2.—*Barometric gradient at Zikawei [3] for the period January to March.*

Year.	Pressure at Zikawei (760+).	Pressure differences. Zikawei—Nafa.	Pressure differences. Zikawei—Izugahara.	Barometric gradient.	Azimuth.
	mm.	*mm.*	*mm.*		*N.—°E.*
1891	8.2	4.3	2.7	4.4	115
1892	8.0	4.9	2.2	4.9	130
1893	8.3	5.0	2.7	5.1	120
1894	8.0	3.4	2.5	3.6	110
1895	7.1	3.2	2.0	3.3	116
1896	8.7	4.1	2.3	4.2	120
1897	8.1	4.6	1.3	4.6	130
1898	6.9	4.1	1.4	4.1	125
1899	8.0	3.8	2.2	3.9	120
1900	8.9	4.7	2.5	4.8	125
1901	9.2	3.9	3.5	4.4	110
1902	7.7	2.2	1.6	2.3	110
1903	8.3	3.4	2.8	3.8	104
1904	7.9	3.7	1.8	3.8	124
1905	7.1	3.5	2.4	3.7	113
1906	7.4	3.9	2.3	4.0	118
1907	8.2	4.3	2.6	4.4	117
1908	8.9	4.2	2.6	4.3	116
1909	7.9	4.6	2.1	4.7	125
1910	7.3	3.8	2.7	4.0	110

[1] *Okada, T.* On the graphical method for finding the barometric gradient. Jour. met'l. soc. Japan, April, 1909, p. 91.
[2] Pressures at Nafa and Izugahara not reproduced here—C. A. jr.
[3] Pressures at Nafa and Izugahara here omitted—C. A. jr.

The data utilized in the above and following calculations are taken from the Annual Reports of the Central Meteorological Observatory, Tokyo, and Bulletin des Observations de l'Observatoire de Zikawei, Année 1910. All the pressure readings have been corrected for standard gravity and reduced to sea level, using the International Meteorological Tables.

II. AIR TEMPERATURE.

3. *Correlation between March barometric gradient at Zikawei and July–August air temperature on the east coast of Japan.*—In summer the anomaly of weather, especially of air temperature, in northeastern Japan is closely connected with the perturbation in the intensity of the Pacific anticyclone. In July and the early part of August the western margin of the grand barometric maximum extends toward the east coast of Hokkaido and sends cooler air currents to our northeastern provinces, causing a fall of temperature there. From my daily exercise in charting the weather materials sent telegraphically from the various parts of Japan and the continent [Asia] I have incidentally noticed that the summer high barometer over the Pacific is preceded by the lower barometer on the continent in the past colder month. I have tried, therefore, to find the correlation, if any exists, between the barometric height on the continent during the winter and the air temperature on the east coast of Japan in the following summer.

In March the anticyclonic system on the continent is in the declining stage. Hence the barometric gradient for March may serve as an index of the remnant activity of the continental [Asiatic] atmospheric center. After many laborious computations and comparisons I have found there exists a well-established interrelation between March barometric gradient (x) at Zikawei and the mean air temperature (y) for July and August at the stations on the east coast of Japan, as can be seen from Table 3. On the east coast of Japan we have three meteorological observatories having long and homogeneous series of observations. Their names and positions are:

Observatory.	Longitude.	Latitude.	Altitude.
			Meters.
Nemuro	145° 35′ E.	43° 20′ N.	26.7
Miyako	141° 59′ E.	39° 38′ N.	30.4
Isinomaki	141° 19′ E.	38° 26′ N.	44.8

In Table 3:—

x = the barometric gradient at Zikawei for March.
Δx = its departure from the average.
y = the mean air temperature at any locality on [Japan's] east coast for July and August.
Δy = its departure from the average.

TABLE 3.—*Correlation between March barometric gradient at Zikawei and July–August air temperatures in northeastern Japan.*[4]

Station.	Zikawei.	Nemuro.	Zikawei.	Nemuro.	July alone.[5] Nemuro.	
Year.	x	y	Δx	Δy	y	Δy
1891	3.35	15.9	+0.24	+0.5	14.6	0.7
1892	5.00	17.2	+1.89	+1.8	17.1	3.2
1893	2.50	15.2	−0.61	−0.2	13.1	−0.8
1894	3.45	16.6	+0.34	+1.2	15.4	1.5
1895	1.95	14.1	−1.16	−1.3	12.4	−1.5
1896	4.05	15.9	+0.94	+0.5	14.1	0.2
1897	3.75	15.0	+0.64	+0.4	13.0	−0.9
1898	4.35	15.5	+1.24	+0.1	14.5	0.6
1899	2.65	15.0	−0.46	−0.4	14.5	0.6
1900	2.70	15.4	−0.41	0.0	12.5	−1.4
1901	2.20	16.0	−0.91	+0.6	14.1	0.2
1902	0.75	13.3	−2.36	−2.1	12.0	−1.9
1903	2.30	14.8	−0.81	−0.6	13.6	−0.3
1904	3.80	17.4	+0.69	+2.0	16.3	2.4
1905	3.75	14.5	−0.64	−0.9	14.3	0.4
1906	3.05	15.0	−0.06	−0.4	14.3	0.4
1907	3.05	15.3	−0.06	−0.1	13.0	−0.9
1908	3.30	14.5	+0.19	−0.9	11.1	−2.8
1909	3.75	15.7	+0.64	+0.3	14.5	0.6
1910	2.55	14.8	−0.56	−0.6	13.3	−0.6
Mean	3.11	15.4	....	....	13.9	....

These results are graphically shown in the diagram, figure 1.

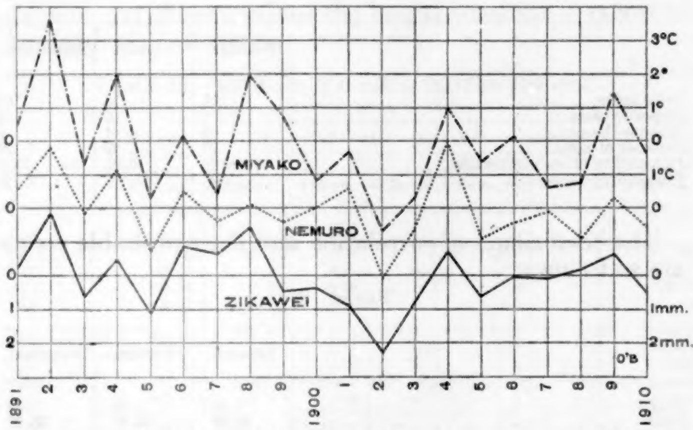

FIG. 1.—Curve of barometric gradient in March at Zikawei (————) compared with temperature departures for the following July at Miyako (—.—.—), and for the following July–August at Nemuro (••••••).

From an examination of the [complete Table 3] we see that the probabilities of a deviation in the same sense and in an opposite sense are:

TABLE 4.

	Nemuro.	Miyako.	Isinomaki.
Same sense	16	13	15
Opposite sense	3	7	3
Intermediate	1	0	2
Number of cases	20	20	20
Probability of the same sense	80%	65%	75%
Probability (corrected)	87.5%	79.5%	82.5%

We see that the probability of the variation in the same sense is therefore very great. Hence the decline in intensity of the Siberian anticyclone in March appears to be associated with a fall of the mean air temperature on [Japan's] east coast in the following July and August.

[4] Values for Miyako and Isinomaki here omitted.
[5] Added from author's Table V, the remainder of which is omitted—C. A. jr.

I have also computed the coefficient of correlation, r, and its probable error, w, by the following formula

$$r = \frac{\Sigma(\Delta x . \Delta y)}{\sqrt{\Sigma(\Delta x)^2 \; \Sigma(\Delta y)^2}}, \qquad w = \pm 0.6745 \, \frac{(1-r^2)}{\sqrt{n}},$$

where n is the number of cases.

The results of the computation are as follows:

TABLE 5.

	Nemuro.	Miyako.	Isinomaki.
$\Sigma(\Delta x)^2$	17.36	17.36	17.36
$\Sigma(\Delta y)^2$	17.89	31.58	29.76
$\Sigma(\Delta x . \Delta y)$	13.32	18.28	15.54
r	+ 0.756	+ 0.781	+ 0.678
w	± 0.065	± 0.059	± 0.081

Hence the smaller the barometric gradient for March on the continent the lower the air temperature in northeastern Japan for July and August.

A similar correlation has been found between the oscillations of the intensity of the action center of the continent in March and the July and August temperatures at other places in Japan, especially in its northeastern provinces; but the correlation is less pronounced on the west side than on the east side of the central mountain ranges.

[Table IV, which is not reprinted, gives the temperature deviation at all stations on either side of the ranges.]

The probability that the sign of the temperature deviation in the different sections of northeastern Japan will be the same as that of the barometric gradient at Zikawei is given in Table 6.

TABLE 6.

Sign.	East side.		West side.					Between the ranges.			
	Abasiri.	Tokyo.	Sapporo.	Suttu.	Akita.	Yamagata.	Niigata.	Kamikawa.	Hakodate.	Aomori.	Hukusima.
Same	16	15	13	12	11	11	13	14	13	14	14
Opposite	2	4	7	5	7	7	6	6	6	6	5
Intermediate	2	1	0	3	2	2	1	0	1	0	1
Cases	20	20	20	20	20	20	20	20	20	20	20
Probability of same sign	80	75	65	60	55	55	65	70	65	70	70

From Table 6 we see that the correlation is fairly established on the east coast and is merely suggestive on the west coast of northeastern Japan.

In northeastern Japan there are two mountain ranges, one of them running along the Pacific coast and the other in the central part of the district. The former is called "Kitakami range" and the latter the "Ō-u range." The flat land between the two ranges is the valley of Kitakami River. The inflowing cool air from the Pacific high is first forced to ascend the steep slope of the Pacific range and descend toward the flat land on the west side of the mountain. Again it ascends the east side of the central range and descends to the coast of the Japan Sea. As the result of pseudo-adiabatic expansion, the cloudiness is increased in these districts, especially on the east sides of the mountains. On the west sides the cooler inflowing air is largely warmed, owing to the adiabatic compression and to conduction from the land surface over which the air flows, and the cloudiness is comparatively less. This ex-

plains that [the] correlation under consideration is less pronounced on the western sides of the mountain ranges than on the eastern or Pacific sides.

4. *Correlation between March barometric gradient at Zikawei and July air temperature on the east coast of Japan.*—In section **3** I have shown that there is a marked correlation between the March pressure gradient at Zikawei and the mean temperature on our east coast for July and August. We shall next examine the correlation between the March gradient at Zikawei and the July temperature at Nemuro and other stations. The last two columns of Table 3 [taken from the author's Table V, which is not reprinted in full] give y and Δy for July alone at Nemuro.

The complete table shows that the probability of a deviation in the same sense is as follows:

TABLE 7.

	Nemuro.	Miyako.	Isinomaki.
Same sense	14	16	15
Opposite sense	6	4	3
Intermediate	0	0	2
Number of cases	20	20	20
Probability in the same sense	70%	80%	75%

The coefficients of correlation and their probable errors are as follows:

TABLE 8.

	Nemuro.	Miyako.	Isinomaki.
$\Sigma(\Delta x)^2$	17.36	17.36	17.36
$\Sigma(\Delta y)^2$	38.59	45.34	43.41
$\Sigma(\Delta x.\Delta y)$	15.77	21.39	16.82
r	+0.609	+0.754	+0.613
w	±0.095	±0.065	±0.094

From the above calculations we see that there is, on the whole, a strongly pronounced resemblance between the intensity of the Siberian anticyclone in March and air temperature on our east coast in the following July.

We give in Table VI [not reprinted] the temperature deviation in July at the other places on either side of the central mountain ranges and shall show that the correlation is most strongly established on our east coast.

Table 9 shows the probability of a July temperature deviation in northeastern Japan, having the same sign as the Zikawei pressure gradient in the preceding March.

TABLE 9.

Sign.	East side.		West side.					Between the ranges.			
	Abasiri.	Tokyo.	Sapporo.	Suttu.	Akita.	Yamagata.	Niigata.	Kamikawa.	Hakodate.	Aomori.	Hukusima.
Same	13	17	13	14	12	15	12	12	14	14	14
Opposite	7	3	6	5	8	5	7	8	4	3	5
Intermediate	0	0	1	1	0	0	1	0	2	3	1
Number of cases	20	20	20	20	20	20	20	20	20	20	20
Probability of the same sign	65	85	65	70	60	75	60	60	70	70	70

5. *Correlation between barometric gradient at Zikawei for January to March and air temperature on the east coast of Japan in August.*—The following Table 10 shows that there is a suggestive correlation between the barometric gradient x at Zikawei for the period January to March and air temperatures on Japan's east coast in August.

TABLE 10.—*Correlation between barometric gradient at Zikawei for January to March and air temperature on the east coast of Japan* [6] *in August.*

Station.	Zikawei.	Nemuro.	Zikawei.	Nemuro.
Year.	x	y	Δx	Δy
1891	4.4	17.1	+0.3	+0.3
1892	4.9	17.3	+0.8	+0.5
1893	5.1	17.3	+1.0	+0.5
1894	3.6	17.8	−0.5	+1.0
1895	3.3	15.8	−0.8	−1.0
1896	4.2	17.7	+0.1	+0.9
1897	4.6	17.0	+0.5	+0.2
1898	4.1	16.4	0.0	−0.4
1899	3.9	15.4	−0.2	−1.4
1900	4.8	18.2	+0.7	+1.4
1901	4.4	17.9	+0.3	+1.1
1902	2.3	14.5	−1.8	−2.3
1903	3.8	15.9	−0.3	−0.9
1904	3.8	18.5	−0.3	+1.7
1905	3.7	14.7	−0.4	−2.1
1906	4.0	15.7	−0.1	−1.1
1907	4.4	17.5	+0.3	+0.7
1908	4.3	17.8	+0.2	+1.0
1909	4.7	16.8	+0.6	0.0
1910	4.0	16.3	−0.1	−0.5
Mean	....	16.8	....	....

The probabilities of a temperature deviation in the same and the contrary sense with the barometric gradient are:

TABLE 11.

	Nemuro.	Miyako.	Isinomaki.
Same sense	16	13	15
Opposite sense	2	6	4
Intermediate	2	1	1
Number of cases	20	20	20
Probability of the same sense	80%	65%	75%
Probability (corrected)	85%	67.5%	77.5%

The coefficients of correlation and their probable errors are as follows:

TABLE 12.

	Nemuro.	Miyako.	Isinomaki.
$\Sigma(\Delta x)^2$	7.59	7.59	7.59
$\Sigma\Delta y)^2$	25.08	52.87	28.07
$\Sigma(\Delta x.\ \Delta y)$	8.38	10.07	8.61
r	+0.607	+0.503	+0.590
w	±0.095	±0.113	±0.098

We have also computed the coefficient of correlation between the difference of the barometric pressures at Zikawei and Nafa for January to March, and air temperatures at our east coast stations in August, and have found the following results:

TABLE 13.—*Correlation between the pressure difference Zikawei–Nafa for January to March, and temperatures in August on the east coast of Japan.*

	Nemuro.	Miyako.	Isinomaki.
$\Sigma\Delta x)^2$	8.30	8.30	8.30
$\Sigma(\Delta y)^2$	25.08	52.87	28.07
$\Sigma(\Delta x.\Delta y)$	8.40	10.33	9.09
r	+0.582	+0.493	+0.596
w	±0.010	±0.109	±0.097
Probability, in the same sense	75%	65%	75%

We give in Table VIII [not reprinted] the temperature deviation in August at other places on both sides of the mountain ranges and the deviation of the barometric gra-

[6] Values for Miyako and Isinomaki not reprinted.—C. A. jr.

diation, whence are derived the following probabilities of a temperature deviation of the same sign as the deviation of the pressure gradient.

TABLE 14.

Sign.	East side.		West side.					Between the ranges.			
	Abasiri.	Tokyo.	Sapporo.	Suttu.	Akita.	Yamagata.	Niigata.	Kamikawa.	Hakodate.	Aomori.	Hukusima.
Same	16	13	12	14	12	13	13	13	13	14	11
Opposite	3	6	5	2	6	6	5	5	5	5	6
Intermediate	1	1	3	4	2	1	2	2	2	1	3
No. of cases	20	20	20	20	20	20	20	20	20	20	20
Probability of the same sign (%)	80	65	60	70	60	65	65	65	65	70	55
Probability (corrected) (%)	80.5	65.5	67.5	80.0	70.0	67.5	70.0	70.0	70.0	72.5	62.5

III. DURATION OF BRIGHT SUNSHINE.

5. *Correlation between the barometric gradient at Zikawei for March and the duration of bright sunshine in northeastern Japan in July.*—The anomaly of the duration of bright sunshine at any station is often due to a local cause. Yet I have ventured to examine whether the correlation between sunshine duration and the general barometric distribution exists or not. In the following Table 15 we give the [deviation in] the duration of bright sunshine at the meteorological stations in northeastern Japan. At these stations the bright sunshine is recorded by Jordan's heliograph.

TABLE 15.—*Deviation of sunshine duration (per cent).*

Year.	Barometric gradient, Zikawei.	July.			August.		
		Nemuro.	Tokyo.	Niigata.	Nemuro.	Tokyo.	Niigata.
1891	+0.24	0	− 8	....	0	+ 2	....
1892	+1.89	+ 9	+ 6	+ 6	+ 6	+ 6	+13
1893	−0.61	− 3	+21	+ 7	+ 8	+ 1	+ 7
1894	+0.34	+ 5	+22	+ 8	0	+ 8	+18
1895	−1.16	+ 7	−11	+ 8	− 1	− 3	0
1896	+0.94	+ 4	+ 1	+ 7	+ 1	+ 3	− 9
1897	+0.64	+ 7	− 4	−18	+11	−10	−13
1898	+1.24	0	+30	+ 4	+ 4	+ 1	+30
1899	−0.46	−10	− 9	−17	− 8	+ 7	− 2
1900	−0.41	+ 6	− 8	+12	+ 1	+15	− 5
1901	−0.91	− 1	−11	+ 1	− 5	+ 5	−10
1902	−2.36	− 5	− 9	−22	− 6	−20	−20
1903	−0.81	− 2	− 4	0	+ 8	+12	−29
1904	+0.69	+ 3	+ 9	+18	+ 7	+15	− 7
1905	−0.64	+ 5	− 4	−26	− 3	−23	+ 3
1906	−0.06	− 9	− 9	− 3	+ 1	− 7	+ 2
1907	+0.06	0	+ 3	+ 4	−15	− 3	+18
1908	+0.19	−10	− 6	+19	+ 4	+ 5	+ 2
1909	+0.64	+ 1	+ 6	+10	− 4	+ 1	+11
1910	−0.56	−12	−14	−11	−10	−17	− 3
Mean	....	32	39	52	32	50	43

The probabilities of a sunshine deviation of the same sign in July and in August, and the coefficients of correlation are shown in Table 16.

TABLE 16.

Sign.	July.			August.		
	Nemuro.	Tokyo.	Niigata.	Nemuro.	Tokyo.	Niigata.
Same	13	15	13	13	14	11
Opposite	4	5	5	5	6	7
Intermediate	3	0	1	1	0	1
Number of cases	20	20	19	20	20	19
Probability	65	75	68	65	70	63
Correlation coefficient	0.37	0.58	0.47	0.41	0.42	0.47
Probable error	±0.13	±0.10	±0.12	±0.13	±0.12	±0.12

From Table 16 we see that on the east coast of northeastern Japan the correlation between the variation of the intensity of the action center in March and duration of bright sunshine is at least a suggestive one. The greater the barometric gradient at Zikawei for March the greater the duration of bright sunshine on our east coast in July and August. But on the west side of the central mountain range in northeastern Japan we could not find any correlation which is worthy of notice. This fact gives a hint for the physical interpretation of this correlation between temperature and barometric oscillations, which will be given in my Second Note.

ANNUAL HOURS OF FOG, 1885-1915.[1]

A compilation of approximate hours of fog or thick weather observed per year at 508 fog-signal stations throughout the [Lighthouse] Service during the period 1885 to 1915, inclusive, has been continued from the records of the Lighthouse Service, along the lines mentioned in the Bulletin for August, 1912. A summary of the principal results is given in Table 1, giving the results for the station in each district having the maximum number of hours of fog in a single year and the station having the highest annual average for the period.

TABLE 1.—*Hours of fog or thick weather, per year, at 508 stations, 1885—1915.*

District.	Number of stations[1]	Mean hours per year for district.[2]	Maximum observed.			Highest annual average.		
			Station.	Hrs.	Year.	Station.	Hrs.	Yrs.
1st	56	874	Seguin	2,734	1907	Petit Manan	1,691	31
2d	36	680	Great Round Shoal L. Vessel.	1,727	1907	Pollock Rip Slue L. Vessel.	1,175	14
3d	100	463	New London Harbor.	1,809	1885	Block Island S. E.	831	31
4th	12	363	Delaware Breakwater.	912	1887	Delaware Breakwater.	525	30
5th	85	218	Cape Henry	902	1904	Baltimore	426	7
6th	7	135	Martins Industry L. V.	320	1898	Brunswick L. V.	183	8
7th	1	112	Egmont Key	128	1913	Egmont Key	112	3
8th	16	281	Cubits Gap	819	1907	Cubits Gap	562	10
10th	15	228	Cleveland Breakwater.	1,224	1915	Buffalo Breakwater.	524	22
11th	47	310	Thunder Bay Island.	1,085	1909	Middle Island	541	11
12th	54	359	Calumet Harbor	2,269	1913	Calumet Harbor	1,196	9
16th	10	278	Scotch Cap	1,144	1915	Cape Hinchinbrook	555	5
17th	29	439	Swiftsure Bank L. V.	1,770	1912	Swiftsure Bank L. V.	1,203	9
18th	40	606	San Francisco L. V.	2,145	1915	Point Reyes	1,337	31

[1] No fog-signal stations in the 9th, 13th, 14th, 15th, and 19th districts. No regular station in the 7th district prior to 1913.

[2] Compiled from the station averages instead of from the annual district averages, as was the case in previous report.

The absolute maximum record at Seguin, Me., of 2,734 hours in 1907, equivalent to about 30 per cent of the entire year (8,760 hours) has not been exceeded. The highest annual average record remains at Petit Manan, Me., being 1,691 hours per year for 31 years, or over 19 per cent of the period. Out of 29 stations in the entire Service averaging over 1,000 hours of fog per year, 14 or practically half are in the first district.

An interesting maximum record is that observed at Calumet Harbor, near Chicago, Ill., in the twelfth district, where 2,269 hours of fog, or about 26 per cent of the year, occurred in 1913. This and other Lake stations are affected somewhat by smoke in the vicinity.

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[1] *Reprinted from* Lighthouse Service Bulletin, December, 1915, No. 48, p. 194.

The former Pacific coast record at Point Reyes, Cal., 2,070 hours in 1887, was exceeded in 1915 by San Francisco Light Vessel, where 2,145 hours were observed, which was the highest figure at any station in the Service during the past year. The highest annual average for the Pacific coast, is, however, still maintained by Point Reyes, being 1,337 hours per year for 31 years, equivalent to about 15 per cent of the time.

While the records for 1915 indicate that fog was not unusually prevalent throughout the Service as a whole, there were 15 stations at each of which over 1,200 hours of fog or thick weather were observed, as follows:

TABLE 2.—*Stations having over 1,200 hours of fog or thick weather, 1915.*

District.	Station.	Hours.	Per cent of year.
18th	San Francisco Light Vessel	2,145	24
1st	Moose Peak	1,508	17
1st	Libby Islands	1,498	17
1st	Egg Rock	1,494	17
1st	Matinicus Rock	1,454	17
1st	The Cuckolds	1,464	17
1st	Whitehead	1,440	16
1st	Mount Desert	1,326	15
1st	Great Duck Island	1,297	15
1st	West Quoddy Head	1,288	15
12th	Milwaukee Pierhead	1,282	15
3d	Point Judith	1,265	14
2d	Pollock Rip Slue L. V.	1,231	14
10th	Cleveland West Breakwater	1,224	14
2d	Vineyard Sound L. V.	1,203	14

THE PHYSICIAN AND THE WEATHER BUREAU.[1]

As far back as in the time of Hippocrates physicians recognized the part which climate plays in man's health and well-being, and to-day it is most desirable that the physician should know (1) where he can secure reliable, unprejudiced climatological information; (2) what elements of climate are recorded in a reliable manner.

Weather Bureau resources.

The U. S. Weather Bureau is officially charged with the collection of a large amount of weather data and the working over of this material into climatological statements. This material is furnished by observations of temperature, atmospheric pressure, vapor pressure, precipitation, wind direction and movement, and the duration of sunshine at about 200 regular stations, most of which also have self-recording instruments for making continuous records of some or all of these elements. The locations of these regular stations are shown by the small circles on the map of figure 1. Besides these regular stations the Weather Bureau maintains (March, 1915) 4,083 special stations served by cooperative observers who observe temperature, cloudiness and rainfall, and wind direction, or perhaps only temperature or rainfall. The number of such cooperative stations in each State is shown on figure 1 by the number placed at the center of each State.

[1] A paper with this title was published in the Journal of the American Medical Association, Chicago, Jan. 1, 1916, 66:6-11, by Ford A. Carpenter. It is here abstracted for the benefit of our readers.—C. A. jr.

The regular stations telegraph their observations twice daily to the central office at Washington, and to selected map-issuing stations, and the combined simultaneous results appear once daily on the printed maps of the daily weather issued by those stations. These weather maps should be of great practical use to the physician in routing his patients according to the weather movements the maps show; and the local bureau office can tell him of average weather conditions, as well as of altitudes along railroad routes over which he considers sending patients.

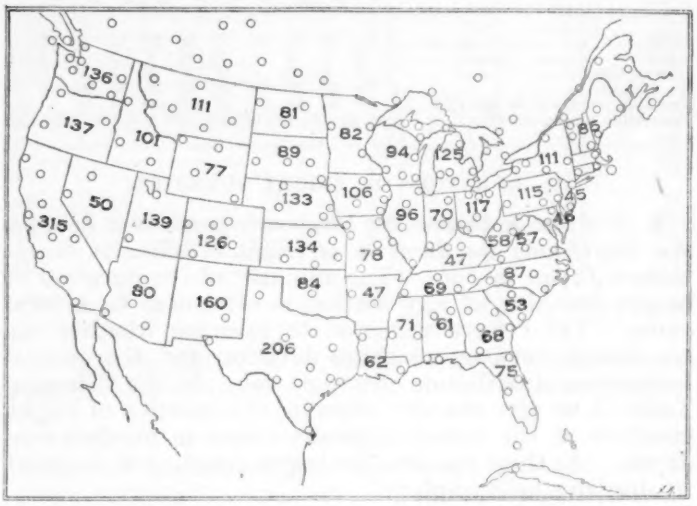

FIG. 1.—Distribution of Weather Bureau stations in the United States. Circles indicate positions of regular stations. Approximate number of cooperative stations in each State is shown by the respective figures.

Of less frequent publications the Weather Bureau issues a large number, practically all of which are at the service of the physician either in his home on request or at the local office of the Weather Bureau in his city. Every station of the service issues on the first of each month a condensed tabular summary of the preceding month's daily weather and this summary (W. B. Form 1030-metl.) is mailed regularly to those requesting it. Furthermore, every climatological section center issues monthly a collection of observations made in the section (State) during the month, a report that can usually be secured upon request. The bureau has also published many special bulletins dealing with the climatology of the United States in its relation to many phases of human activity. Bulletin Q, "Climatology of the United States," deserves special mention as the most comprehensive and thorough study of the climate of the United States; it is available at each of the Weather Bureau stations and is also found in many public libraries. Since 1873 the bureau has also published the MONTHLY WEATHER REVIEW, which now contains many special contributions as well as detailed monthly discussions and statistics of each month's weather. The Weather Bureau library of more than 32,000 titles in meteorology and climatology is also for public use.

In addition to placing available meteorologic records at the disposal of the applicant, the Weather Bureau officials throughout the country will be found prompt

and courteous in their treatment of applicants for data, whether made in person or through correspondence. In many instances they will render unexpectedly valuable aid to the physician in giving him clear and concise data, perhaps not comprehended in their official routine, yet none the less accurate and satisfactory. From their training they are keen observers and their judgment on climatic matters is free from local prejudice.

Climate and health.

It was long since shown that mere pressure changes, even of such amounts as 300 millimeters mercury in 24 hours, do not have injurious effects on sick people; daily experience shows that the range in pressure from day to day is not in excess of that experienced when riding from the ground floor to the top of high office buildings, or perhaps a tenth of an inch of mercury (2.5 mm.) in the barometric column. The weather that accompanies changes in pressure is found to have more important effects upon the human organism.[2]

Again, sunshine and ventilation (natural air movement or windiness) are found to be most important elements of climate in its relation to health, and the data for studying them are furnished by the Weather Bureau.

PROBLEMS FOR THE CLIMATOLOGIST.

Various problems in applying Weather Bureau skill and resources arise—e. g., proper selection of sanatorium sites; "sensible" temperatures (now estimated by means of wet-bulb thermometer observations) as related to infant mortality; acute infectious diseases and sunlight (as mapped on the bureau's monthly sunshine charts). Here the Weather Bureau can only supply observational material.

On the other hand, the bureau may and does properly take up on its own behalf very intensive studies of the climatic details of quite restricted areas—e. g., special stations established in southern California; also the study of the minute climate of 16,000 acres of the old Spanish grant Los Palos Verdes, between Redondo Beach and San Pedro near Los Angeles, Cal., by means of six complete meteorological stations; or the detailed studies into local conditions in the frost-free belts (thermal belts) of North Carolina by means of a large number of recording instruments exposed in the orchards of the region.

A California physician has prepared the following statement of the ways in which a physician may properly claim the assistance of the Weather Bureau:

> I believe the field has been but little explored. We physicians are guilty of many things; among them is guessing. If the U. S. Weather Bureau will prove some of this guessing true or false, it will add one more good thing to its past fine record. I think that the time is near at hand when our health officers will be required to be specialists. They will then have the time, the special training, and other equipment to go into the subject in conjunction with your bureau and give us some scientific findings. I think the State should be plotted, showing the real atmospheric conditions of all localities and showing the influence on the functions of the body. Whether the old east wind of Boston is accountable for all of the vile things charged to it or not, nobody really knows, but it should be investigated. That altitude, temperature, humidity, prevailing and unusual winds have much effect on many individuals, there is no doubt. The nasal and pulmonary mucous membranes are constantly affected by atmospheric conditions. Locally I have observed that semichronic bronchial coughs that do not yield readily in the city will often clear up in a few hours in the mountains and foothills east of the city. A congested nasal mucous membrane that will kick up a rumpus much of the time in the mountains will disappear promptly at a lower elevation near the coast. Some patients with bronchial asthma that is incurable in the business section of the city will be very comfortable a short distance out of town and in a higher, drier location. Two hot dry days last month have been charged up with some rather serious pulmonary conditions in aged people. These are a few instances of hundreds coming to my mind that I have observed in my years of practice. The subject should be worked out by a union of effort of the Weather Bureau and the medical profession.

ALTO-CUMULUS WITH VIRGULUS.

By C. FITZHUGH TALMAN, Professor of Meteorology.

[Library, Weather Bureau, Washington, Feb. 26, 1916.]

The type of cloud described by Mr. George Reeder in the MONTHLY WEATHER REVIEW for December, 1915, page 614, under the name "Aurelia alto-cumulus," has frequently been described before—e. g., by C. Ritter, "Essai d'une théorie provisoire des hydrométéores" (Ann. Soc. Mét. de France, 1880, **28**: 117), and by J. Vincent, "Atlas des nuages," 1907, p. 17. Both authors present drawings of this cloud, and Vincent agrees with Ritter in calling it "alto-cumulus with virgulus," the last word being arbitrarily formed from the Latin *virga*, a wand or switch. Lastly, there is a splendid photograph of this form of cloud in Loisel's "Atlas des nuages," Paris, 1911, figure 13. Loisel also uses Ritter's nomenclature.

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[2] *Hann* (Ward Tr.), Handbook of Climatology.
Browning, C. C., Trans. Amer. clim. assoc., 1913, 29.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR JANUARY, 1916.

By H. C. FRANKENFIELD, Professor of Meteorology.

[Dated: U. S. Weather Bureau, Washington, Feb. 8, 1916.]

GENERAL PRESSURE DISTRIBUTION OVER THE UNITED STATES AND CANADA, INCLUDING THE SANDWICH AND ALEUTIAN ISLANDS, ALASKA, AND THE WESTERN PORTION OF THE MIDDLE ATLANTIC OCEAN.

The month was remarkable for the persistence of abnormally-high pressure waves over the Aleutian Islands, Alaska, and the middle Atlantic Ocean. There were but two days during the month, the 5th and 19th, when pressure fell below the normal over the Aleutian Islands and Alaska, then only to a very moderate extent, and followed quickly by a rapid rise to much above normal conditions. Over the North Atlantic there were three falls to slightly below normal conditions—on the 3d, 8th, and 17th. At the same time uniformly low pressure prevailed over the South Pacific, as indicated by reports from Honolulu, with a marked fall and severe storms from the 16th to the 18th, inclusive. There were only two days, the 1st and 29th, when the pressure at Honolulu was above the normal, and then only a tenth of an inch or so. There was, however, a marked fall in pressure at Sitka on the 19th and 20th, which did not extend to the northward. In the Pacific States low pressure prevailed throughout the month with a few unimportant exceptions, and on January 27 the barometer at San Francisco read 28.84 inches, the lowest pressure (reduced to sea level) ever recorded at that station. The previous record of low pressure was 29.12 inches on February 21, 1891. To the eastward of the Pacific States there was quite a regular succession of high and low areas, some of them of quite marked character, but as a rule they did not reach the Atlantic States, as the prevailing high pressure over the ocean diverted them after they reached the central portion of the country so that they moved northeastward over the Upper Lake Region and from thence east-northeastward.

The general result of this distribution was a prolonged period of heavy rains and snows in the Pacific States, snows in the plateau region, and rains and snows over the central portion of the country, and quite dry weather in the Atlantic and east Gulf States. Coupled with this there was very cold weather over the Northwest and extreme West and very warm weather over the Atlantic and Southern States. Over the cold districts many of the thermometer readings were the lowest of record, while over the warm districts readings equaling or exceeding previous high records for the month of January were frequent.

STORM WARNINGS.

On the morning of the 2d a western disturbance of quite marked character was central over eastern upper Michigan with a trough extending southeastward into a secondary depression over the District of Columbia, and southwest storm warnings were ordered from Delaware Breakwater to Boston. The storm did not develop further and only moderately strong winds occurred. During this time pressure was quite high over the Northwestern States, but during the 3d another disturbance from the West moved rapidly eastward, and on the morning of the 4th it was central over northwestern Lake Superior, with strong high pressure to the southeastward. Southwest storm warnings were accordingly ordered at 11 p. m. from Delaware Breakwater to Eastport, Me., and fresh to strong southwesterly gales occurred, following the eastward passage and increasing intensity of the storm. On the morning of the 5th the warnings were extended southward to Washington, N. C., and strong southwest gales also occurred over that section. The warnings were changed to northwest from Delaware Breakwater to Eastport at 11 p. m. of the 5th, and the gale did not subside until after the morning observation of the 6th. On the morning of the 6th the warnings from Baltimore to Washington, N. C., were changed to northwest, but were lowered at 9 p. m., as the winds diminished by afternoon.

By the morning of the 7th a moderate disturbance had developed over western North Carolina and, as pressure was quite high to the northeastward, northeast storm warnings were ordered from Norfolk, Va., to Hatteras, N. C., at 10:30 a. m. Moderate northeast gales occurred during the day and night and until after the morning observation of the following day.

On the morning of the 9th pressure was very low over the Northwestern States with a strong gradient to the eastward, and at 9 a. m. advisory messages for strong southerly winds were sent to open ports on Lake Michigan, and winds occurred as forecast. This same disturbance continued quite rapidly eastward, and at 11 p. m. of the 9th southwest warnings were again ordered from Hatteras to Eastport. There was also a secondary depression over southeastern Colorado with a strong gradient to the southeastward, and southeast warnings were ordered at the same time on the Gulf coast from Mobile, Ala., to Carrabelle, Fla. Strong winds occurred along the Atlantic coast as forecast, but there were none on the Gulf, as the Colorado disturbance failed to develop, and the warnings were therefore lowered at 10 a. m. of the 10th. At 11 p. m. of the 10th the warnings on the New Jersey coast were changed to northwest, while the southwest warnings on the New England coast were continued, the storm at that time being central over the Province of Ontario. The storm moved more to the northeastward than had been anticipated, and the warnings on the Atlantic coast were lowered at 10:30 a. m. of the 11th. Another disturbance from the North Pacific had been moving southwestward, and by the night of the 11th it had reached north central Texas with a strong and very cold high area to the northward, resulting in very sharp gradients in both pressure and temperature. Advisory warnings were therefore sent to open ports on Lake Michigan for increasing northeast winds with snow. This forecast was fully verified. On the morning of the 12th the disturbance was over southern Illinois with the cold high area still to the northwestward. There was also a secondary disturbance near the mouth of the Rio Grande, and southwest storm warnings were ordered at 12 noon on the Gulf coast from Mobile to Carrabelle. At 6 p. m. southeast storm

warnings were also ordered on the Atlantic coast from Portsmouth, N. H., to Delaware Breakwater, and at Baltimore and Washington. At 4 p. m. the southwest warnings on the Gulf coast were extended to Rockwell, Fla., and at 11 p. m. the southeast ones on the Atlantic coast were extended over the Maine coast and southward to Jacksonville. Again the southern disturbance failed to develop to any great extent and the winds on the Gulf and south Atlantic coasts were no more than fresh, while on the north coast they were fresh to strong. No more warnings were ordered until 11 p. m. of the 16th, when the rapidly rising pressure over the interior of the country, following another western disturbance that was then over the lower St. Lawrence Valley, indicated increasing west to northwest winds on the Atlantic coast, and northwest warnings were therefore ordered at 11 p. m. from Hatteras to Boston. Fresh west to northwest gales occurred on the following day.

On the morning of the 18th a disturbance from the Hudson Bay country was central over western Ontario with increasing intensity, and special observations indicated increasing southerly winds on the north Atlantic coast. Southwest storm warnings were therefore ordered at 3:30 p. m. from Sandy Hook, N. J., to Nantucket, Mass., and moderate southwest to west gales occurred. By the morning of the 19th the storm had passed into the Gulf of St. Lawrence and the warnings were lowered. There was at this time still another disturbance of marked character over western South Dakota with strong pressure gradient to the eastward, and advisory warnings of fresh to strong southerly winds, with snow, were sent to open ports on Lake Michigan. On the evening of the 19th these conditions occurred as forecast. At 4 p. m. of the 20th southwest warnings were ordered from Delaware Breakwater to Eastport, on account of the rapidly decreasing pressure from the western disturbance. Some moderately strong winds occurred on the night of the 20th, but by the morning of the 21st they had diminished greatly and the warnings were accordingly lowered at 9 a. m.

The western storms continued their rapid succession. On the morning of the 22d there was another to the north of Lake Superior, and southwest storm warnings were again ordered from Sandy Hook to Boston, and at 2:30 p. m. extended southward to Atlantic City. At the same time advisory messages for strong northwesterly winds and much lower temperature were sent to open ports on Lake Michigan. All of these conditions occurred as forecast and there were severe southwesterly gales on the north Atlantic coast.

There was no further occasion for warnings until the 28th, when a disturbance from the southwest had reached the Canadian Maritime Provinces by way of the Upper Lakes. Special observations indicated rapidly rising pressure to the westward, and northwest storm warnings were therefore ordered at 1 p. m. from Sandy Hook to Nantucket. Moderate to fresh west to northwest gales occurred and also extended northward along the entire New England coast.

On the morning of the 31st the last disturbance of the month extended from the mouth of the Rio Grande northeastward to Georgian Bay, with the principal center of depression over the latter region. Special observations indicated a further development of this section of the low area and, at 3 p. m., southwest storm warnings were accordingly ordered from Delaware Breakwater to Eastport. There was, however, no further development in the intensity of the storm so that only fresh winds resulted, and on the morning of February 1 the warnings were ordered down.

COLD WAVES AND FROSTS.

The great feature of the weather in the United States for the month was the north Pacific disturbance that first appeared on the 5th day of the month. An offshoot from this disturbance moved eastward on the 7th and 8th, but it disappeared north of Lake Superior. Another offshoot on the following day developed more character and moved east-southeastward with increasing intensity, dividing into two sections during the night, one over southeast Minnesota and the other over southeast Colorado. The southern end soon disappeared, but the northern one continued eastward over the usual track, and was followed by a strong high area that first appeared over Alberta on the morning of the 9th. This high area developed rapidly to the southeastward and eastward with below-zero temperatures, and there was every indication that it would extend eastward following the offshoot from the Pacific disturbance, but the main disturbance itself began to move southeastward during the night of the 9th–10th and continued along the western slope of the mountains, reaching central Texas by the night of the 11th. This movement interfered with the eastward progress of the cold wave and high area to the northward, but at the same time the high area continued to increase in magnitude and intensity and the temperatures continued to fall, so that on the morning of the 12th, with the disturbance extending in a narrow trough from east Texas to Lake Michigan, very cold weather prevailed to the westward and northward, with a minimum reading of 58° below zero at Prince Albert, Saskatchewan, and with the line of zero temperature extending to the Kansas-Oklahoma boundary. Below-zero temperatures also prevailed in the Middle Plateau and freezing temperatures in the Pacific States. To the eastward and southward of the disturbance there was an abnormal rise in temperature with a maximum reading of 80° at Meridian, Miss., during the 12th, equaling the January record at that station. On the morning of the 13th the center of the disturbance was over Ontario and the crest of the high area had moved southeastward over the Missouri Valley. The cold wave had continued in the Northwest, had become more intense in the Plains States, and had extended to the Texas coast, where the temperatures were from 4° to 6° below the freezing point. The line of zero temperature had also extended eastward as far as the Illinois-Indiana line and into the northern Upper Lake Region. Snows and rains and severe gales attended the movement, and the usual storm warnings were displayed on the Atlantic and Gulf coasts and cautionary advices were frequently sent to open ports on Lake Michigan. Cold-wave warnings had been ordered on the first appearance of the high area over the Canadian Northwest, and they were gradually extended until between the 10th and 13th they had been ordered for practically the entire country except the Pacific States.

On the morning of the 14th the temperature had fallen decidedly in the Atlantic and east Gulf States, except over central and southern Florida, and low temperatures continued elsewhere, but with a rising tendency west of the Mississippi River. There was at this time another north Pacific disturbance central over northern Nevada and pressure was again rising over the Canadian northwest. The disturbance moved to the southeastward with

decreasing intensity, reaching west Texas by the evening of the 15th. In the meantime another disturbance from the southern Hudson Bay country had moved southeastward to extreme western Ontario. Both disturbances then continued eastward with rapidly rising pressure following from the Northwest, and, beginning with the 16th, cold-wave warnings were again ordered over the western portion of the Washington forecast district and extended on the night of the 16th throughout the district generally, except the upper Lake region, and cold waves occurred as forecast, the line of freezing temperature extending into northeast Florida on the morning of the 18th.

On the morning of the 17th a marked Pacific disturbance was central off the coast of southern California attended by very heavy rains, while strong high pressure continued to the northeastward. The disturbance moved northeastward to Hudson Bay during the next three days, but a secondary disturbance that developed during the 20th over Colorado moved northeastward to eastern Nebraska by the morning of the 21st, while another disturbance of still more marked character was central north of Montana, with rapidly rising pressure and much lower temperatures closely following. At 8 p. m. of the 21st the Nebraska disturbance was north of Lake Superior, while the Canadian one had passed east of Manitoba with cold weather to the westward, and cold-wave warnings were accordingly ordered for upper Michigan. Early in the afternoon of the 22d cold-wave warnings were also ordered for lower Michigan, but another severe disturbance from the north Pacific intervened and the fall in temperature over upper Michigan, while decided, was not sufficient to justify a cold wave. Over lower Michigan there was practically no fall in temperature. The last-mentioned disturbance moved eastward and, on the morning of the 24th, it extended from eastern Colorado to western Lake Superior in very moderate form, with another very cold high area to the northwestward. Cold-wave warnings were accordingly ordered early in the afternoon for the northern portion of lower Michigan, but again a low pressure area from the West interfered and the warnings were not verified. This low area on the morning of the 26th was central over western Colorado, the general depression extending southeastward into western Texas and thence northeastward into Iowa, while to the northward pressure remained very high, with low temperatures. As pressure continued to rise in the Northwest, cold-wave warnings were ordered on the night of the 26th for the Ohio Valley and lower Michigan, but the low area moved northeastward by way of the upper Mississippi Valley and the upper Lake region, and the fall in temperature, while ranging from 20° to 30°, was not sufficient to justify the hoisting of the cold-wave warnings.

However, the temperature at Havre, Mont., at 8:15 a. m. of the 27th fell to $-56.7°$ F., or lower than any previous January record at that station, and was also the very lowest recorded temperature there for any month of any year. At 7 a. m. the temperature was $-55°$ F. and at 8 a. m. it was $-56°$. On the night of the 27th cold-wave warnings were ordered for western and northern New York, the upper Ohio Valley, and east Tennessee. This warning was practically verified, and the cold wave extended into New England.

As low pressure still persisted throughout the Central-West and Southwest, with the cold high area to the northwestward, cold-wave warnings were ordered on the night of the 29th for Mississippi and western Tennessee, but the Central-West disturbance moved very slowly and the warnings were ordered down on the following morning.

It will be noted that many of the cold waves forecast failed of verification, and this failure must be attributed solely to the abnormal movement of the western low areas, which was almost uniformly to the north-northeastward after reaching the southern Plains States. This abnormal movement was, of course, due to the prolonged and unprecedented persistence of the high area over the western Atlantic Ocean, which was maintained with almost undiminished strength throughout practically the entire month, notwithstanding the fact that at different times there were some evidences of its partial dissolution at least.

DISTRICT WARNINGS DURING JANUARY.

Chicago district.—January averaged very cold throughout the Northwest, with frequent temperature changes, and cold-wave warnings for some portion of the district were issued on 20 days during the month. The warnings of the 1st, 3d, 14th, 25th, and 30th were for a small part of the district, covering only one or two States, while those of the 4th, 5th, 9th, 10th, 11th, 12th, 15th, 21st, 22d, 23d, 24th, 26th, 27th, 29th, and 31st covered larger areas. The most important warnings were those of the 4th, covering the pronounced cold wave of the 5th throughout the Northwest, those of the 9th for the cold wave over the northern half of the district, those of the 11th–12th for the severe cold wave of the 13th in the upper Mississippi Valley and western Lake region, and those of the 23d–24th for the cold wave of the 24th–25th in Montana, the Dakotas, and Nebraska.

Heavy-snow warnings were issued for northeast and central Minnesota on the 1st and for northern Wisconsin and northern and eastern Minnesota on the 26th.—*Chas. L. Mitchell, Assistant Forecaster.*

Denver district.—The month was stormy and more than the usual number of special warnings were issued.

Frost warnings of the 11th, 12th, and 31st for southern Arizona were fully verified, while the warnings, generally for local frost, of the 7th, 13th, 19th, and 20th were verified in part. The warning of the 15th was a failure; instead of frost, rain set in.

A cold-wave warning was issued on the morning of the 4th for north-central Colorado and in the evening for eastern Colorado. While sharp falls occurred, temperatures did not reach verifying values. The anticyclone's influence was lessened by a remnant of low pressure left along the foothills of the Continental Divide.

The cold-wave warning on the evening of the 9th, for eastern Colorado and northeastern New Mexico, was fully verified only along the middle eastern border of Colorado. The course of the anticyclone was too far eastward, probably due to increasing domination of the low west of the mountains.

On the morning of 11th cold-wave warnings were issued for Colorado, northern New Mexico, northern Arizona, and southern and eastern Utah. These warnings were fully verified, the cold wave being confined entirely to the areas specified.

The cold-wave warning of the 15th for the vicinity of Denver, southeastern Colorado, and northeastern New Mexico was fully verified in southeastern Colorado and in northeastern New Mexico, except in the mountains near Santa Fe. For Denver the warning gave only 12 hours' notice.

On the 21st a cold-wave warning was issued for north-central Arizona. This warning was fully verified.

A warning on the 24th for eastern Colorado was fully verified only in extreme northeastern Colorado. The course of the anticyclone was too far eastward.

Warnings were issued on the 26th for western Colorado, northwestern New Mexico, northern Arizona, and southern Utah. These places were visited by a cold wave 24 hours after the expiration of the regulation period. Falling pressure in the west and the southeastward movement of high pressure on the eastern slope delayed the occurrence of the cold west of the mountains.

Warnings issued on the 27th for eastern New Mexico and the 31st for southeastern New Mexico were not verified. The course of the anticyclone was deflected too far eastward.—*Fred. H. Brandenburg, District Forecaster.*

New Orleans district.—Cold-wave warnings were issued on the night of the 10th for Oklahoma and the Texas Panhandle; they were extended on the 11th and 12th over the interior of Texas, Arkansas, and Louisiana to the Gulf coast. An unusually severe cold wave prevailed, with temperatures below zero, over the northwestern portion of the district, 10° F. to 16° F. over the interior of Texas and Louisiana, with freezing on the Gulf coast. The temperature was 22° to 28° in the sugar and trucking region.

Warnings were ordered on the 15th for a cold wave for the northern portion of west Texas, Oklahoma, and the northwest portion of east Texas, and they were extended on the 16th to the Gulf coast. A decided fall in temperature occurred throughout the district, giving temperatures of 18° to 14° over the northern portion of the district, 16° to 24° over the interior, and freezing to the Gulf coast.

On account of an area of high pressure and cold weather, which persisted over the northern Rocky Mountain region from the 24th to the 26th, cold-wave warnings were ordered over Oklahoma and the northwestern portion of Texas on the afternoon of the 24th, and repeated on the 25th and 26th. The high pressure and cold wave remained stationary until the night of the 26th, when a cold wave visited the northwestern portion of the district. The warnings were extended during the 26th and 27th over Arkansas, northern Louisiana, and to the Texas coast. The movement of the cold wave southeastward was retarded, and while a decided fall in temperature occurred over the district, the required minimum temperatures were recorded at only a few stations.

Cold-wave warnings were issued for Arkansas, northern Louisiana, and the interior of eastern Texas on the afternoon of the 29th, but the high pressure area off the south Atlantic coast persisted and the warning failed of verification.

Cold-wave warnings for southern Texas were issued on the morning of the 31st and for southern Louisiana on the night of the 31st. They were justified by resulting conditions.

Storm warnings were ordered for portions of the west Gulf coast on the 11th, 12th, 16th, 20th, and 27th, and verifying winds occurred at some stations, except in the case of the warning issued on the 27th.—*I. M. Cline, District Forecaster.*

Portland, Oreg., district.—A number of storm warnings were issued during the month. All were justified and nearly all verified. Wind velocities of 60 miles an hour were recorded on several days at Tatoosh Island; but the most severe storm of the month was on the 22d, when a current velocity of 94 miles an hour from the south was recorded at North Head, Wash.

A cold-wave warning for southern Idaho was issued on the 15th and was verified by a 20-degree fall in temperature at Pocatello, viz, from 20°F. to 0°F. in 12 hours. There was only a 10-degree fall at Boise.—*T. F. Drake, Local Forecaster.*

San Francisco district.—January, 1916, was unusually stormy on the California coast and many storm warnings were issued. Some of the warnings were not verified by wind velocities from coast stations, but the masters of vessels arriving in port generally agreed that the warnings were justified by outside conditions.

Warnings of floods were issued to southern California points on the 18th and 27th, and were amply justified.

On the afternoon of the 27th, a severe storm passed inland just south of San Francisco, causing the lowest barometer readings on record at many stations. The minimum sea-level pressure at this station was 28.84 inches. Shortly after the passage of the center the wind at Point Reyes Light registered an extreme velocity of 102 miles an hour from the northwest.—*Geo. H. Willson, District Forecaster.*

SECTION IV—RIVERS AND FLOODS.

FLOODS OF JANUARY-FEBRUARY, 1916, IN THE LOWER MISSISSIPPI AND IN SOUTHERN CALIFORNIA.

By ALFRED J. HENRY, Professor in Charge of River and Flood Division.

[Dated: Washington, D. C., Feb. 29, 1916.]

SYNOPSIS.

The general rains of December 24–25, and again of the 27th–29th, 1915, while not producing severe floods, laid the foundation for a flood of great magnitude in the Mississippi from Cairo to the Gulf during February, 1916. The rains of January, 1916, were sufficient to keep the majority of tributary streams at a relatively high stage; several flood waves passed into the Mississippi from the rivers of Arkansas. The climax resulted from rainstorms of January 21–22 and the prolonged general rains of the 25th–31st. The rains of the first period were heavy over northeastern Oklahoma, southwestern Missouri, and northern Illinois, and caused sharp flood waves in the Neosho and Verdigris, tributaries of the Arkansas; also in the latter below the mouth of the Neosho. A record-breaking flood also resulted in the upper Illinois and its main tributaries, the Des Plaines, Kankakee, and Fox Rivers.

The rains of the second period covered the tributaries of the Arkansas in eastern Oklahoma and southern Missouri, and were especially heavy over the Ozark Plateau of southern Missouri, central and eastern Arkansas, southern Illinois, southern Indiana, and immediately along the Ohio below Louisville.

While the flood waves in each of the tributary streams did not reach the trunk stream conjointly, their approach was so timed as to produce a rather flat and prolonged swell from Cairo south. The fact that the rivers of Arkansas, which had been contributing large volumes of water throughout the month, delivered a heavy flow upon a river already in flood will account for the record-breaking stages in the Mississippi between Arkansas City, Ark., and Natchez.

Less water came out of the Ohio in 1916 than in 1913 and the flood at Cairo was naturally one of less magnitude and, moreover, the weather in 1916 turned cold immediately the rains ceased. That fact had a tendency to reduce the run-off in the Ohio basin as compared with 1913.

In that stretch of the Mississippi from Arkansas City to Natchez, Miss., with the single exception of Greenville, Miss., the previous records of high water were overtopped by amounts ranging from 0.6 foot at Lake Providence, La., to 1.4 feet at Vicksburg, Miss. These high stages may be attributed to two facts: First, as already stated, a greater quantity of water came out of the Arkansas and White Rivers in 1916 than in 1913, and second, the levees throughout that stretch of the Mississippi remained intact.

DETAILED NARRATIVE.

Meteorological conditions.

The weather control during the greater part of the month was apparently centered in two great highs, one purely continental and the other partly oceanic and partly continental. The continental high stretched from Alaska southeastward to the northeastern Rocky Mountain slope and the upper Missouri Valley. During the first and second decade of the month this high—or more correctly a series of highs—was effective in causing lows to enter the continent from the Pacific at a lower latitude than usual. The oceanic and continental high in the east extended from the western Atlantic in the neighborhood of Bermuda westward over the continent to the summits of the Appalachians. This high appears to have been effective in shunting lows which had advanced southeastward to about the one-hundredth meridian, thence northeastward across the Lake region to Canada. Further details are given in Section III, Forecasts, and by Chart No. III, Tracks of Centers of Low Areas.

Floods.

Hawaii.[1]—Record-breaking rains fell in Hawaii. At Honolulu the rainfall during the first 18 days of the month amounted to 14.73 inches, of which 7.05 inches fell during the week that ended January 24, 1916. At four other points in the island of Oahu the rainfall for the same week ranged from 10 to 17 inches. On Maui heavy rains began on the 16th, continued until about 5 a. m. of the 18th, when a veritable cloudburst swept over portions of the island, causing a flood that devastated the Iao Valley, with a loss of 11 lives and a large amount of property. A measured rainfall of 8.85 inches in 24 hours was recorded.

California.—It seems reasonable to suppose that the storm which swept over Hawaii on the 18th–19th passed inland over California on the 27th. It is charted as Low No. XIV, Chart III. About a week previous Low No. X, Chart III, passed inland over the middle California coast on the 17th, crossed the south-central part of the State on the 18th, and then moved northeastward into Wyoming by the morning of the 19th. During its movement over the south-central portion of California the storm slackened its progressive movement somewhat, meanwhile giving very heavy rains over the counties of southern California. Light rains had fallen during the previous three or four days and conditions were unusually favorable for a high run-off in connection with the heavy rains of the 17th and 18th—see Tables 11 to 16. The resulting floods were severe and much damage was done to railroads, bridges, highways, land under cultivation, and to the harbor of Los Angeles, by reason of the mass of silt deposited thereon.

A second deluge of rain descended upon the counties of southern California in connection with Low No. XIV, mentioned in a preceding paragraph. The second storm was of much shorter duration. At San Diego, Cal., the rain began at 7:18 p. m. of the 26th and ended at 7:45 p. m. on the 26th. The total fall amounted to 2.41 inches. This rainstorm was attended by unusually high winds for southern California, the average velocity at San Diego being about 30 miles per hour, with a maximum of 54 miles from the south at 4:29 a. m. of the 27th. The reservoirs in the county whence the water supply of

[1] The facts here given were compiled from newspaper clippings. Detailed information as to the precipitation will appear in the Weather Bureau reports of the Hawaiian ection issued at Honolulu by A. M. Hamrick, meteorologist.

the city of San Diego is drawn were already nearly full as a result of the rains of the previous week and all of them, evidently, were not in a condition to withstand the added strain put upon them by the rains of the 26th–27th.

The lower Otay Dam broke during the afternoon of the 27th and released a total of 11,000,000,000 gallons of water. The flood thus created swept everything before it, over a strip of territory said to be 15 miles long and 2 miles wide. It is said that the reservoir held back by the lower Otay Dam had never before been filled.

Meager reports indicate serious loss in the San Luis Rey, Warner, Ti Juana, Mission, Cottonwood, El Cajon, and San Dieguito valleys in San Diego County, Cal. Further details of floods in other California rivers will be found in Table 1 on page 31.

Arizona.—Rains during the six days, January 15–20, that ranged from 3 to 4 inches on the lowlands and probably more on the uplands, started floods in the Gila and its tributaries on the afternoon of the 16th. By the afternoon of the 19th the Roosevelt Reservoir became full and the overflow added greatly to the seriousness of the situation on the lower Salt and Gila Rivers. By the evening of the 25th, however, the rivers had returned within their banks.

A second period of rains began on the 26th and ended on the 30th. Again the rivers passed flood stage, the second flood passing into the Colorado on the closing days of the month, with a crest 2 feet lower than the flood of the 21st. The details of both floods for three stations in Arizona are shown in Table 1, and Table 17 gives the details of rainfall in Arizona.

Arkansas River and tributaries—The Arkansas was not in flood except below the mouth of the Neosho. The flood was due to two periods of heavy rains over the watersheds of the Neosho, the Verdigris and the main stream, where it passes through northeastern Oklahoma. Practically all of the smaller streams in Sequoyah, Haskell, Le Flore, Latimer, Pittsburg, Wagoner, Washington, and Nowata Counties, Okla., were swollen to an unusual height in the second period of heavy rains. There were two wave crests at Forth Smith and at other points along the Arkansas in northeastern Oklahoma—see the Fort Smith hydrograph in fig. A. J. H. 1 (XLIV—10). The first was caused by heavy rains on the 20th–21st. In the four days of fair weather that followed the rivers had receded to about half a foot below the flood stage at Fort Gibson and Fort Smith, whereupon a second period of rains set in. These later rains were not so intense as those first named, but were of much greater duration, continuing from the 26th to the 31st.

In the Neosho watershed the rains of the first period fell upon ground that was covered with 2 inches of ice. The high temperatures attending the rains caused a rapid melting of the ice cover and naturally a run-off that must have been very great. The Neosho in the neighborhood of Iola, Kans., was covered by ice 7 inches in thickness. The breaking up of the ice and the few gorges that were formed added to the height of the flood wave that passed down that river. The damage along the Neosho was confined principally to bridges, highways and levees in Allen, Neosho, and Labette Counties.

There was but a single crest in the Arkansas below Fort Smith, as at Little Rock. The river at that point was above the flood stage from January 29 to February 6, the crest being 27.3 feet on February 2 (flood stage 23 feet). It is probable that somewhat higher crest stages would have been recorded had the river remained within its banks at all places. Gage heights are given in Table 2.

Rivers of Missouri.—The Grand River at Chillicothe crested at 24.3, 6.3 feet above flood stage, on the 24th, due to heavy rains of the 21st and the subsequent breaking up of the ice.

While the rains of the 21st were heavy over the headwaters of the Osage they were less heavy over the lower stretches of the river. At the close of the month the Osage at Bagnell was 4.2 feet above flood stage and rising. While this flood synchronized with that from the Gasconade, both floods came out later than that from the Grand, and as a result the lower Missouri did not quite reach flood stage—see hydrograph for Hermann, Mo. Flood stage at that point is 21 feet. Gage heights appear in Table 3.

Rivers of Illinois.—The region of northeastern Illinois, especially over the watersheds of the Fox, Des Plaines, and Kankakee Rivers, received a heavy fall of rain from the same storm that swept over northeastern Oklahoma. There was also a snow cover of about 3 inches at the beginning of the rains, which melted rapidly, on account of high temperatures. The average 24-hour rainfall in the watershed of the Illinois River above La Salle was not far from 1.5 inches. The area of the watershed above La Salle is 11,649 square miles. The amount of water falling over this region on the 21st aggregated 931,000 acre-feet. If half that amount reached the streams, it would have required about five days, assuming a discharge of 50,000 second-feet, to pass any given point. The hydrograph for La Salle shows that the peak of the flood was about 24 hours in passing and that the river was above flood stage as late as February 15, when the last report was received. Details of floods in rivers of Indiana and Illinois appear in Table 4.

Rivers of Indiana.—The rains which caused severe floods in the upper Illinois on the 20th–21st did not overspread Indiana, but the second period of rains, beginning January 26 and concluding on the 31st, were especially heavy over southern Indiana and, together with lighter rains in the northern portion, caused very general floods in all of the streams of the State. The hydrograph of the lower Wabash at Mount Carmel, Ill., shows the duration and intensity of the flood in the principal river of the State.

Rivers of Kentucky and Tennessee.—The rivers in these States were in flood during the early days of the month, due to rains in the last few days of December and again on January 1 and 2. Heavy rains during the period January 11–13 were instrumental in keeping the rivers at moderately high stages. Gage heights appear in Table 5.

Ohio River.—The Ohio was not at flood stage during January, 1916, above Cincinnati, Ohio, and the flood at that place was both of short duration and little intensity. At Louisville, Ky., the flood stage was reached on the 13th, the river cresting on the 15th with a stage of 31.2 feet, 3.2 feet above flood stage. The above-named flood was separate and distinct from the flood in the lower Ohio during the closing days of the month. The lower Ohio was in flood practically the whole month—see gage heights in Table 6 at Evansville, Ind. The first flood may be considered as beginning December 20, 1915, and ending about January 28, 1916. Immediately thereafter a second flood set in, which crested at 40.2 feet on February 4, and at Cairo with a stage of 53.4 on the same date. There were, however, three distinct swells at Evansville during the period December 20, 1915, to January 28, 1916—see Table 6.

Mississippi River.—The river was frozen at and north of Dubuque throughout the month. At Davenport, although an ice gorge had formed immediately below the mouth of Rock River about the close of December, 1915, the river opposite the city was open for a part of the time. The heavy rains of the 20th–21st, and again on the 26th–27th, coupled with a spell of high temperature in the closing days of the month, created much apprehension in the cities of Davenport and Rock Island, but flood stages were not reached until February 2.

Hannibal, Mo.—The warm weather and rains, as described in the preceding paragraph, caused a slight flood at Quincy, Ill., on the 28th, Hannibal, Mo., on the 29th, and Louisiana, Mo., on the 30th.

St. Louis, Mo.—The light swell mentioned in the preceding paragraph passed St. Louis on February 1, 1916, at a crest of 31.2 feet (flood stage 30 feet), the highest January stage independent of ice conditions reached since 1861. Three days later it reached Cairo, with a crest of 53.4, or 8.4 feet above flood stage. In the 1913 flood the crest stage at St. Louis was but 27.4 feet. The increase in Mississippi water was more than offset by much less Ohio water in 1916 as compared with 1913, crest stages in the last-named river being as much as 8 feet lower in 1916 than in 1913. The flood wave in the Ohio that crested at Evansville on the 18th with 43.6 feet was the greatest of the several swells that came out of the Ohio during January and February, 1916, but it was not supported by relatively high stages in the Mississippi, the stage at St. Louis being but 13.8 feet on the same date. Hence the main Ohio crest reached Cairo on a falling Mississippi and, since the Ohio at Evansville continued to fall until the 28th, the only effect of this crest was to keep the Mississippi below Cairo at relative high stages until the crest produced by the rains of January 21–31 descended upon it.

Memphis, Tenn.—The Mississippi at this station was in flood continuously from January 6 to February 23, cresting at 43.5 feet on February 9, or 3 feet lower than in 1913. Peculiar interest attaches to the Memphis crest stages for the reason that it affords the first opportunity in several years of noting the gage relations between Cairo and Memphis, with a full river and the levees holding. In the early years, when the St. Francis River carried the overflow water escaping from the Mississippi in the neighborhood of Cairo, the Memphis crest was as much as 15 or 16 feet lower than Cairo. With the extension of the levees to and above Cairo, the overflow is prevented, and naturally the difference between the Cairo and Memphis gage heights decreased. In the 1912 flood the difference sank to 8.7 feet. In 1913, with a break in the levees a short distance above Memphis, the difference between crest stages was 8.3 feet, or practically the same as in 1913, but in 1916, with levees intact, the difference amounted to 9.9 feet. Plotting Cairo stages above 45 feet against Memphis stages five days later, it is seen that the relation between the two gages is fairly constant, the Memphis gage being very nearly 10 feet lower than Cairo, except with falling stages at Cairo, when the difference becomes less, as might be expected. With a falling river at both points the difference is 8 feet or less, as against 10 feet with a rising river at Cairo—gage heights in Table 7.

Vicksburg district, including Arkansas City, Ark., Greenville and Vicksburg, Miss.—Previous high stages at Arkansas City were overtopped by 1.0 foot, at Vicksburg by 1.4 feet, at Lake Providence by 0.6 foot. The previous high record at Greenville, 51.3 feet in 1912, was, however, not overtopped.

It should be remembered that previous floods in this district caused levees to give way and hence the recorded crest stages were lower than they would have been had the levees remained intact, as in the present flood. The increased crest stages of the present flood therefore represent the water that in former floods flowed through crevasses in the levees. A table of crevasses during recent years follows:

Year.	Number of crevasses in third district.
1897	7
1903	3
1912	3
1913	1
1916	0

New Orleans district.—On February 28 the flood had not yet passed into the Gulf; the stage at New Orleans had about come to a stand at 21.0 feet. Gage heights appear in Table 7.

Other floods in January, 1916.—Aside from the flood in the Mississippi above described, there were brief floods in the rivers of southwestern Arkansas, in the headwaters of the Trinity River of Texas, and in the rivers of the Gulf drainage in Mississippi, Alabama, and Georgia. Also in the Atlantic drainage of South Carolina and Georgia, as shown in Tables 8 and 9.

BROKEN LEVEES, FLOODS OF JANUARY-FEBRUARY, 1916.

The following list of breaks in levees during the floods of January-February, 1916, has been compiled in the River and Flood Division, mainly from newspaper reports. These reports fail to show whether the broken levees were private, State, or Federal, but it is believed that the great majority were of private ownership.

Arizona.—Government levee on Colorado near Yuma gave way January 22. Town of Yuma and thousands of acres of agricultural land on both sides of the river were inundated.

California.—Levees near Bakersfield on Kern River gave way January 18.

Arkansas, White River, and tributaries.—Break in levee in upper White River, night of January 30, 18 miles south of Batesville, Ark., caused loss of several hundred head of cattle and large quantities of winter wheat.

A series of breaks in the levees of the upper Cache and Current Rivers, tributaries of the White, released large volumes of water. On January 31 a sheet of water about 16 miles wide extended from the Missouri State boundary to Newport, Ark.

The Jacksonport levee at Newport, Ark., broke during the night of January 31, resulting in a stage of water several feet deep in the streets of the town.

The M'Clelland levee, near Cotton Plant, Woodruff County, Ark., broke on the 31st, releasing considerable water from the lower Cache River, about 25 miles north of its junction with the White.

Wash from levee breaks in Greene County flooded bottom lands tributary to the St. Francis River, January 31.

Arkansas River in Arkansas.—The entire drainage area of the Arkansas River from Fort Smith to its mouth was in flood during the last few days of January and the first part of February. Levees were overtopped in many places along the main stream and the entire levee system on several of the tributaries was severely damaged. Detailed reports are missing.

Levees were reported broken near Van Buren, Crawford County, on the night of January 29. The Arkansas was out of its banks at Ozark, Franklin County, and the river was 5 miles wide at several places. Gravel deposits caused permanent injury to farming land in many places along this stretch. Cattle and stored crops were lost, but the warnings minimized the loss to a large extent.

At Neely bend, 8 miles east of Dardanelle, and at a point 20 miles east, breaks occurred during January 30, flooding about 6,000 acres of arable land. It was estimated that the loss of stored crops totaled 10 per cent of the annual crop.

A break at Index, Conway County, February 1, severed communications with a large area to the west and submerged lowland property.

The largest break occurred at Cummins, on the main river, on February 1, releasing great volumes of water, which spread over large portions of Lincoln and Desha Counties and the northern half of Drew and Chicot Counties. It is estimated that over 200,000 acres of farming land were inundated and several lives were reported lost. At this date traffic is still demoralized and detailed estimates of the damage are not available.

A break at State Farm, on the White River, a few miles north of its junction with the Arkansas, near Stuttgart, flooded lowlands between the White and Arkansas and choked the bayous draining into the Arkansas below its junction with the White.

Rivers of southwestern Arkansas.—The Red River of Arkansas went out of its banks January 29, severely damaging the newly completed levees.

The Ouachita left its banks on the same date, in Clark and Ouachita Counties, flooding thousands of acres of arable land.

The Saline River, January 30, broke out of its levees on the west side and inundated portions of Drew and Ashley Counties.

A private levee protecting the Waldo-Magnolia railway broke January 31, near Waldo, Columbia County, and was expected to be a total loss.

Lower Mississippi River.—The levee at West Hickman, Ky., gave way and water backed up into Hickman, January 31.

The levee on the right bank of the Mississippi near Newellton, La., gave way, February 15. The overflow passed into the old basin of Lake St. Joseph and the speed of the flow was thereby retarded, so as to enable the inhabitants of the lowlands to escape. Portions of Franklin and Catahoula and the larger part of Tensas and Concordia Parishes were overflowed.

Atchafalaya.—The levee broke on the right bank of the Atchafalaya, 8 miles below Melville, February 13, but was closed during the afternoon of the 14th.

The levee again broke, February 15, 6 miles below Melville, on the right bank, forming a crevasse 1,000 feet wide. The flood waters extended over St. Landry and the east portion of St. Martin Parishes.

Wabash River of Indiana.—The levee at La Fayette gave way on February 1, submerging the lower section of the town.

The levee at Attica, Fountain County, was under 2 feet of water February 1. Portions of Warren County were inundated.

Flood waters overtopped the levee at Covington. Severe loss to stored crops resulted.

The Conover levee in west Terre Haute broke, February 2, inundating 1,000 acres of built-up suburban property.

The Honey Creek levee, 8 miles south of Terre Haute, broke February 2, because of backwater from the Wabash; 15,000 acres of farming land were inundated.

The levee protection along Wild Cat Creek, a tributary of the Wabash north of La Fayette, overflowed February 1. Escaping waters did considerable damage in the vicinity of Kokomo, Ind.

White River, West Fork.—The West Washington Street levee in Indianapolis, Ind., broke during night of January 31, but was kept from giving way entirely. Portions of Morgan, Greene, and Martin Counties were overflowed by escaping water from levee breaks. Shoals, Martin Co., reported the river out of its banks for the third time in five weeks.

On the lower stretches of the river, Daviess County suffered from inundation of thousands of acres of farming land. Much winter wheat was lost; highways, embankments, railway property, and bridges were washed out.

White River, East Fork.—Blue River, Flat Rock, Brandywine, and Sand Creeks were out of their banks from January 31 to February 2. Levee at Shelbyville, Shelby Co., on the Blue River, broke during the night of January 31, releasing a large volume of water which spread over lowland farms.

LOSS OF LIFE AND PROPERTY.

There has been much conflicting evidence as to the loss of life in the floods above considered. The official in charge at the Weather Bureau office in San Diego places the loss of life occasioned by the breaking of the lower Otay Dam at 18, and there appear to be fairly well authenticated reports of the loss of 8 lives in Los Angeles and adjoining counties, making the total for southern California 26.

Three lives were lost in northeastern Oklahoma, 16 at various points in Arkansas, 3 in the vicinity of Newellton, La., making a total of 22 in the Great Central Valley and a grand total of 48 during the month.

The property loss has been placed at amounts ranging from $1,000,000 to $7,000,000. Effort is being made to obtain a conservative estimate of the loss in the various flood-stricken regions. The loss in the Great Central Valley, so far as crops are concerned, is not large, although it is much too early to make a final report.

STAGES ATTAINED DURING THE JANUARY FLOODS.

The following tables (1 to 10) have been compiled in accordance with the uniform plan adopted in 1915 and followed in previous flood discussions during 1915 in this REVIEW. These tables show: (1) Name of river and place where it was in flood, (2) flood stage and the time during which the river was above its flood stage, (3) the crest stage and the date on which it was reached at the place mentioned. Table 10 gives a comparison of stages attained during previous floods in the Mississippi.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

TABLE 1.—*Floods in the rivers of the Pacific slope, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Willamette	Eugene, Oreg	10.0			9.0	24
Salt	Tempe, Ariz	7.0	17	25	18.7	19
Do	do	7.0	28	31	17.0	29
Gila	Florence	5.0	17	25	11.0	20
Do	do	5.0	28	31	9.0	28
Colorado	Yuma, Ariz	(?)			32.8	22
Sacramento	Jacinto, Cal	21.0			18.2	24
Do	Knights Landing, Cal.	18.0			17.3	28, 29
Do	Red Bluff, Cal	23.0			22.0	25
Do	Sacramento, Cal	29.0			24.8	28
San Joaquin	Lathrop, Cal	17.0			16.2	30, 31
Kings	Piedra, Cal	12.0	17	18	18.6	17
Mokelumne	Bensons Ferry, Cal	12.0			10.2	29
Mormon Slough	Bellota, Cal	20.0			17.8	17

TABLE 2.—*Floods in the Arkansas River and tributaries, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Arkansas	Tulsa, Okla	16.0			10.0	21
Do	Fort Smith, Ark	22.0	22	31	32.7	30
Do	Dardanelle, Ark	20.0	23	31	29.5	31
Do	Little Rock, Ark	23.0	29	[1] 6	27.3	[1] 6
Do	Pine Bluff, Ark	25.0	29	[1] 7	29.6	[1] 3
Neosho	Iola, Kans	10.0	22	22	11.4	22
Do	Oswego, Kans	20.0	22	24	21.7	23
Do	Wyandotte, Okla	25.0	23	23	25.0	23
Do	do	25.0	29	29	25.6	29
Do	Fort Gibson, Okla	22.0	22	25	26.8	23
Do	do	22.0	27	31	29.5	30
Verdigris	North Muskogee, Okla.	21.3	28	31	24.0	28
N. Canadian	Oklahoma, Okla	12.0			7.2	28
Canadian	Calvin, Okla	15.0			11.2	21
Fourche la Fave Creek.	Bigelow, Ark	23.0	29	31	28.8	31
Black	Black Rock, Ark	14.0	1	31	26.5	31
White	Calico Rock, Ark	18.0	14	15	20.5	14
Do	do	18.0	28	31	51.0	31
Do	Batesville, Ark	18.0	14	16	20.6	15
Do	do	18.0	29	31	35.4	31
Do	Newport, Ark	26.0	16	18	27.4	17
Do	do	18.0	30	[1] 12	33.4	[1] 1
Do	Georgetown, Ark	22.0	3	[1] 19	27.5	[1] 3 & 4
Do	Clarendon, Ark	30.0	30	[1] 8	38.5	[1] 8

[1] February.

TABLE 3.—*Floods in the Missouri River and tributaries, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Missouri	Boonville, Mo	21.0			16.8	23
Do	Hermann, Mo	21.0			19.6	28
Grand	Chillicothe, Mo	18.0	22	25	24.3	24
Osage	Bagnell, Mo	28.0	28	31	32.2	31
Gasconade	Arlington, Mo	12.0	29	31	21.9	31

TABLE 4.—*Floods in the rivers of Ohio, Indiana, Illinois, and Michigan, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Mahoning	Youngstown, Ohio	7.0	2	4	9.3	3
Muskingum	Zanesville, Ohio	25.0			24.3	3
Do	McConnelsville, Ohio	22.0	3	4	23.6	3
Do	Marietta, Ohio	32.0	4	5	33.7	4
Walhonding	Walhonding, Ohio	8.0	2	4	12.5	2
Tuscarawas	Norris Point, Ohio	8.0	1	5	11.6	3
Do	Coshocton, Ohio	8.0	2	5	13.4	2
Scioto	Prospect, Ohio	10.0	2	4	12.8	3
Do	Bellpoint, Ohio	9.0	2	2	9.0	2
Do	Columbus, Ohio	17.0			16.8	2
Do	Circleville, Ohio	7.0	2	5	14.5	3
Do	do	7.0	12	15	13.5	14
Do	Chillicothe, Ohio	14.5	3	4	18.0	4
Do	do	14.5	14	15	16.4	15
Olentangy	Delaware, Ohio	9.0	2	2	10.8	2
Little Miami	Kings Mills, Ohio	17.0	13	13	17.8	13
Miami	Sidney, Ohio	10.0	2	2	10.2	2
Do	Piqua, Ohio	12.0			10.9	2
Do	Tadmor, Ohio	12.0	2	3	15.4	2
Do	do	12.0	13	13	12.1	13
Do	do	12.0	31	31	13.9	31
Do	West Milton, Ohio	10.0	2	3	11.3	2
Do	do	10.0	31	31	16.0	31
Mad	Springfield, Ohio	10.0			8.3	13
Sandusky	Upper Sandusky, Ohio.	13.0	2	2	13.5	2
Do	Tiffin, Ohio	10.0	2	4	12.3	3
Do	Fremont, Ohio	10.0	2	3	12.0	2
St. Joseph	Montpelier, Ohio	10.0	4	5	10.8	5
Do	do	10.0	22	23	11.6	23
Do	do	10.0	31	31	10.6	31
Auglaize	Defiance, Ohio	10.0	1	6	12.8	4
Maumee	Napoleon, Ohio	10.0	33	6	12.6	4
Do	Fort Wayne, Ind	15.0	3	8	20.6	6
Do	do	15.0	31	31	18.8	31
Wabash	Bluffton, Ind	12.0	3	5	14.5	4
Do	Logansport, Ind	12.0	3	4	12.6	4
Do	do	12.0	31	31	12.9	31
Do	La Fayette, Ind	11.0	3	9	20.5	5
Do	do	11.0	13	16	17.9	15
Do	do	11.0	22	25	15.9	23
Do	do	11.0	29	31	21.6	31
Do	Terre Haute, Ind	16.0	4	18	18.5	9
Do	do	16.0	31	31	18.7	31
Do	Mount Carmel, Ill	15.0	1	31	22.6	21
East Fork White	Shoals, Ind	20.0	13	19	24.4	18
Do	do	20.0	31	[1] 8	32.0	[1] 4
West Fork White	Anderson, Ind	12.0	3	3	14.8	3
Do	do	12.0	31	[1] 1	16.1	31
Do	Noblesville, Ind	14.0	2	3	16.1	2
Do	do	14.0	31	[1] 2	18.8	[1] 1
Do	Indianapolis, Ind	12.0	2	5	17.0	4
Do	do	12.0	31	[1] 2	20.8	[1] 1
Do	Elliston, Ind	19.0	2	9	26.1	7
Do	do	19.0	12	17	23.7	16
Do	do	19.0	30	[1] 7	30.2	[1] 2
White	Decker, Ind	18.0	1	28	22.8	20,21
Do	do	18.0	30	[1] 12	26.8	[1] 6
Illinois	La Salle, Ill	18.0	4	14	19.6	9
Do	do	18.0	16	[2] 1	32.9	22
Do	Peoria, Ill	16.0	22	27	23.1	25
Do	Beardstown, Ill	12.0	6	(*)	20.7	[1] 1 & 2
Grand	East Lansing, Mich	7.5	22	23	8.8	22
Do	Portland, Mich	11.6	26	26	13.2	26
Do	Grand Rapids, Mich.	11.0	22	25	13.2	23

* 13.3 on Mar. 8, 1916. [1] February. [2] March.

TABLE 5.—*Floods in the rivers of Tennessee, Kentucky, West Virginia, Pennsylvania, and New York, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Tennessee	Knoxville, Tenn	12.0	8	9	13.7	9
Do	Chattanooga, Tenn	33.0			32.9	1
Do	Florence, Ala	18.0	2	6	19.3	3
Do	Riverton, Ala	32.0	1	8	38.8	4
Do	Savannah, Tenn	40.0			38.9	6
Do	Johnsonville, Tenn	31.0	4	10	32.5	8
Watauga	Elizabethton, Tenn	8.0	7	9	9.4	9
North Fork Holston	Mendota, Va	8.0	8	8	12.0	8
Cumberland	Celina, Tenn	45.0			38.1	2
Do	Carthage, Tenn	40.0	3	4	41.2	3
Do	Nashville, Tenn	40.0	2	8	42.4	5
Do	Fox Bluff, Tenn	43.0			42.9	8
Do	Clarksville, Tenn	46.0	2	11	49.2	8
Green	Rumsey, Ky. (Lock 2)		?	?	30.1	6-8
Kentucky	Frankfort, Ky	31.0			28.1	14
Licking	Falmouth, Ky	28.0			27.2	13
Big Sandy	Louisa, Ky. (Lock 3).	20.0	12	15	25.6	13
Little Kanawha	Glenville, W. Va	22.0	12	12	28.2	12
Do	Creston, W. Va	20.0	12	13	24.0	12
Cheat	Rowlesburg, W. Va	12.0			11.5	12
Monongahela	Fairmont, W. Va	25.0	12	12	26.3	12
Do	Greensboro, Pa	20.0	12	12	24.1	12
Do	Lock, No. 4, Pa	31.0	13	13	31.5	13
Kiskiminetas	Saltsburg, Pa	8.0			7.8	2
Shenango	Sharon, Pa	9.0	2	4	10.9	3
Beaver	Beaver Falls, Pa	10.6			10.5	3
East Branch Delaware.	Fishs Eddy, N. Y	10.0			9.7	21
Mohawk	Little Falls, N. Y	6.0	28	28	6.8	28
Do	Tribes Hill, N. Y	16.0			15.4	28
Do	Schenectady, N. Y	15.0	29	29	15.0	29

TABLE 6.—*Floods in the Ohio River, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Ohio	Pittsburgh, Pa	22.0			20.7	3
Do	Beaver Dam, Pa	30.0	3	3	30.7	3
Do	Marietta, Ohio	33.0			32.0	5
Do	Parkersburg, W. Va	36.0			32.8	5
Do	Point Pleasant, W. Va.	40.0			39.0	1
Do	Catlettsburg, Ky	50.0			45.7	15
Do	Portsmouth, Ohio	50.0			49.3	15
Do	Maysville, Ky	50.0			48.8	15
Do	Cincinnati, Ohio	50.0	3	3	50.0	3
Do	do	50.0	13	17	53.2	14
Do	Madison, Ind	46.0	14	16	47.1	15
Do	Louisville, Ky	28.0	14	18	31.2	15
Do	Cloverport, Ky	40.0	3	9	43.1	5
Do	do	40.0	12	21	46.7	16,17
Do	Evansville, Ind	35.0	1	26	43.6	18
Do	do	35.0	31	[1] 13	40.2	[1] 4
Do	Henderson, Ky	33.0	1	26	42.1	18
Do	do	33.0	31	[1] 14	38.6	[1] 6
Do	Mount Vernon, Ind	35.0	1	28	44.5	19
Do	do	35.0	30	[1] 18	42.5	[1] 8
Do	Shawneetown, Ill	35.0	1	[1] 10	47.4	20,22
Do	Paducah, Ky	43.0	7	27	45.7	18,19
Do	do	43.0	[1] 2	[1] 13	45.0	[1] 9
Do	Cairo, Ill	45.0	6	17	51.8	[1] 4

[1] February.

TABLE 7.—*Floods in the Mississippi River, January and February, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Mississippi	Davenport, Iowa	15.0	....	....	14.2	Jan. 25
Do	Keokuk, Iowa	14.0	....	....	13.1	28
Do	Warsaw, Ill	17.0	27	27	17.7	27
Do	Quincy, Ill	14.0	28	30	15.1	28
Do	Hannibal, Mo	13.0	28	31	15.3	29
Do	Louisiana, Mo	12.0	24	24	12.0	24
Do	....do	12.0	28	[1]1	15.0	30
Do	Grafton, Ill	18.0	29	[1]5	23.4	31
Do	St. Louis, Mo	30.0	31	[1]2	31.5	31
Do	Chester, Ill	30.0	31	[1]4	30.8	Feb. 2
Do	Cape Girardeau, Mo.	30.0	29	[1]7	36.4	3
Do	New Madrid, Mo	34.0	4	[1]19	41.9	[1]6
Do	Memphis, Tenn	35.0	6	[1]23	43.5	[1]10
Do	Helena, Ark	42.0	7	[1]29	53.4	[1]11
Do	Arkansas City, Ark	42.0	4	(2)	56.4	[1]10-11
Do	Greenville, Miss	42.0	18	[3]5	50.7	[1]11, 14
Do	Vicksburg, Miss	45.0	17	(2)	53.9	[1]15
Do	Natchez, Miss	46.0	24	(2)	53.6	[1]15
Do	Baton Rouge, La	35.0	28	(2)	42.6	[3]1-3
Do	Donaldsonville, La	28.0	30	(2)	34.0	[3]1
Do	New Orleans, La	18.0	31	(2)	21.0	[1]28

[1] February. [2] Still above flood stage, Mar. 10, 1916. [3] March.

TABLE 10.—*Highest river stages at various places during the floods of 1882, 1897, 1903, 1912, 1913, and 1916.*

Station.	River.	Highest stage.					
		1882	1897	1903	1912	1913	1916
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cincinnati, Ohio	Ohio	58.6	61.1	53.2	53.4	70.0	43.7
Evansville, Ind	....do	44.9	43.6	42.4	42.6	48.4	40.2
Nashville, Tenn	Cumberland	55.1	48.7	40.7	46.5	44.9	15.5
Johnsonville, Tenn	Tennessee	43.8	48.0	33.7	35.4	33.3	25.0
Paducah, Ky	Ohio	49.9	50.9	47.6	49.9	54.3	45.0
Cairo, Ill	....do	51.8	51.6	50.6	54.0	54.8	53.4
Kansas City, Mo	Missouri	......	22.8	[1]35.0	23.2	21.9	9.5
Hannibal, Mo	Mississippi	7.0	20.8	[1]22.5	19.0	14.3	15.3
St. Louis, Mo	....do	28.2	31.0	[1]38.0	30.8	27.2	31.5
New Madrid, Mo	....do	......	......	39.5	44.0	44.5	41.9
Memphis, Tenn	....do	35.0	37.1	40.1	45.3	46.5	43.5
Helena, Ark	....do	47.2	51.8	51.0	54.4	55.2	53.4
Little Rock, Ark	Arkansas	25.7	21.4	24.8	24.0	17.3	27.3
Arkansas City, Ark	Mississippi	......	51.9	53.0	55.4	55.1	56.4
Yazoo City, Miss	Yazoo	......	31.5	28.7	30.4	29.8	29.9
Vicksburg, Miss	Mississippi	48.8	52.5	51.8	52.1	52.3	53.9
Natchez, Miss	....do	......	49.8	50.4	51.4	52.4	53.6
Alexandria, La	Red	34.8	26.3	36.2	33.6	24.2	36.7
Baton Rouge, La	Mississippi	......	40.6	40.0	43.8	41.3	42.6
Donaldsonville, La	....do	......	32.8	32.2	34.8	32.7	34.0
New Orleans, La	....do	15.8	19.5	20.4	22.0	20.5	21.0
Monroe, La	Ouachita	......	37.9	44.5	46.2	36.9	40.6
Simmesport, La	Atchafalaya	......	......	......	50.1	46.9	......
Melville, La	....do	......	36.1	38.7	41.9	41.7	41.9

[1] Occurred later than the lower Mississippi flood.

TABLE 8.—*Floods in the Red River and the rivers of the West Gulf States, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Red	Fulton, Ark	28.0	29	31	30.6	31
Ouachita	Arkadelphia, Ark	18.0	28	28	18.0	28
Sabine	Logansport, La	25.0	....	....	24.2	31
Sulphur	Ringo Crossing, Tex.	20.0	....	....	19.0	29, 30
Do	Finley, Tex	24.0	30	31	25.0	31
Trinity	Dallas, Tex	25.0	23	25	28.5	25
Do	....do	25.0	27	31	34.9	30
Do	Trinidad, Tex	28.0	30	31	30.4	31

TABLE 9.—*Floods in the rivers of the East Gulf and South Atlantic States, January, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Atchafalaya	Melville, La	37.0	26	(2)	41.9	[3]1-4
Tallahatchie	Swan Lake, Miss	25.0	10	(2)	29.1	[3]11-14
Yazoo	Yazoo City, Miss	25.0	28	(2)	29.9	[1]18
Pearl	Edinburg	21.0	2	4	23.0	3
Do	Jackson, Miss	20.0	4	16	26.7	9, 10
West Pearl	Pearl River, La	13.0	18	31	15.0	27
Black Warrior	Tuscaloosa, Ala	46.0	23	25	52.9	23
Tombigbee	Demopolis, Ala	39.0	1	11	50.2	5
Alabama	Montgomery, Ala	35.0	1	3	43.0	1
Do	Selma, Ala	35.0	1	6	43.1	3
Chattahoochee	Alaga, Ala	30.0	1	3	33.0	2
Ocmulgee	Abbeville, Ga	11.0	5	8	12.2	7
Saluda	Chappells, S. C	14.0	1	1	15.8	1
Wateree	Camden, S. C	24.0	1	1	26.8	1
Santee	Rimini, S. C	12.0	1	10	15.2	5
Do	Ferguson, S. C	12.0	1	13	13.9	6
Roanoke	Weldon, N. C	30.0	1	1	33.3	1

[1] February. [2] Still above flood stage, Mar. 10, 1916. [3] March.

FLOOD-PRODUCING RAINS OF JANUARY.

The depths of rainfall day by day in the counties of southern California are shown in tabular form in Tables 11 to 16, inclusive. These data are furnished in advance of their regular publication through the courtesy of District Forecaster George H. Willson, of San Francisco, Cal. Table 18 is a résumé of the data of Tables 11 to 17, stated in the form of the daily average precipitation in southern California and Arizona.

Ordinarily the greater the area covered the less will be the average precipitation, since precipitation usually progresses from west to east, and when summed by dates may not be uniform over the entire district, being less on the eastern front as the storm approaches and diminishing on the western front as the storm recedes. Other considerations, such as altitude and exposure to the winds, tend to make the horizontal distribution extremely irregular, but when grouped by the smaller political divisions, such as counties, we should expect greater uniformity in depth, level for level, and in general a more uniform horizontal distribution than when greater areas are grouped together.

Table 19 gives the average daily precipitation in those watersheds east of the Rocky Mountains in which the streams were in severe flood. These data have been supplied in advance of their regular publication by the section directors of the several States concerned. The courtesy of the several directors is here acknowledged.

The rainstorm of the 21st in Oklahoma moved rapidly to the northeast over the Great Lakes on the afternoon of the 21st, and the weather in its rear cleared rapidly. There was practically no rain of consequence after 8 a. m. of the 22d. The precipitation of this storm was heaviest in northeastern Oklahoma and northern Illinois. Between these two regions the rainfall in the storm's path was considerably lighter. This fact is not brought out in Table 19, hence we have compiled Table 20, showing the rains of 2 inches and over in 24 hours along the storm track from Oklahoma to northern Illinois, and also for other dates and places. This table represents the local variation in intensity that in general attends widespread rainstorms.

The second period of rains east of the Rockies began late on the 25th and continued intermittently until the 31st. The intensity varied on the several dates, as may be gathered from the data of Table 20. A region of marked local intensity is found in eastern Oklahoma on the 27th–28th, in southern Missouri and in the immediate drainage of the Ohio in Illinois, Indiana, and western Kentucky on the 29th and 30th. Outside of these regions (see A. J. H. fig. 2, XLIV—11) precipitation was light to moderate and did not form an important contribution to the floods.

In general, the depths of rainfall east of the Rockies in the first period were not sufficient, under the average conditions of ground absorption, to have produced flood stages, but the sleet-ice cover in southeast Kansas and southwest Missouri and the snow cover in northern Illinois evidently prevented any considerable ground absorption at first. Hence the rapidity with which the rivers reached flood stage. At the close of the first period of rains the temperature was above freezing and the ground, in Arkansas at least, free of frost. The rains in the beginning of the second period were light to moderate, but increased in intensity during the second day and continued moderately heavy for the three consecutive days, January 28–31, 1916. (See Table 19, for Arkansas, Missouri, Illinois, and Indiana.)

TABLE 11.—*Daily precipitation in Ventura County, Cal., January 16–20 and 24–29, 1916.*

Stations.	Altitude.	January—					Total.	January—						Total.
		16	17	18	19	20		24	25	26	27	28	29	
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Camarillo	....	*	3.30	1.30	0.25	0	4.85	0.07	0.55	0	1.43	1.86	0.05	3.86
Ojai Valley	900	*	5.85	2.15	.28	0	8.28	.18	.70	*	3.95	T.	.47	5.30
Ozena	3,680	2.80	1.32	.49	0	0	4.61	.07	.14	.41	1.00	.09	.18	1.89
West Saticoy	150	.28	3.00	1.35	.33	0	4.96	.13	.34	1.88	1.88	0	.25	4.48
Daily means[1]	....	1.56	2.58	1.32	.22	0	5.68	.11	.43	.82	1.82	.49	.24	3.91

TABLE 12.—*Daily precipitation in Los Angeles County, Cal., January 16–20 and 24–29, 1916.*

Stations.	Altitude.	January—					Total.	January—						Total.
		16	17	18	19	20		24	25	26	27	28	29	
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Alhambra	....	*	5.40	3.00	1.10	0	9.50	0	0	0	3.00	0	0.40	3.40
Arcadia	....	*	5.00	4.00	.56	0	9.56	0	1.00	0	1.02	1.60	.50	4.12
Azusa	540	0.02	6.10	4.76	.95	0.16	11.99	T.	1.17	0.10	1.26	1.57	T.	4.10
Bassett	....	.04	3.20	3.00	.72	.50	7.46	0	.45	.08	1.40	1.40	0	3.33
Camp Bonito	2,000	.05	5.18	8.90	1.60	.20	15.93	0	.76	.05	1.54	3.32	0	5.67
Claremont	1,200	.07	4.68	4.41	.82	.42	10.40	T.	.61	.16	1.20	2.19	.58	4.74
Clearwater Power House	2,350	*	*	4.40	.30	0	4.70	0.17	.25	*	1.85	0	.50	2.77
Compton	....	.05	2.02	.78	.60	.07	3.52	.07	.56	.07	2.34	.68	0	3.72
Covina	....	*	4.45	3.65	.70	0	8.80	.75	0	0	1.15	1.65	.53	4.08
Duarte	....	.05	5.20	4.92	.45	.45	11.07	0	1.08	.07	1.18	1.70	0	4.03
El Monte	....	*	4.80	2.62	.67	.15	8.24	.50	0	1.25	1.38	.40	.40	3.93
Fairmont	3,047	0	2.58	3.07	.52	.09	6.26	0	.13	T.	.67	.41	.02	1.23
Iron Forks	3,500	0	*	*	16.75	0	16.75	*	*	*	4.55	0	.60	5.15
Long Beach	....	.12	1.85	.48	.40	.08	2.93	0	.45	.08	2.80	.58	.07	3.98
Lordsburg	....	0	7.40	3.65	.90	0	11.95	0	.83	0	3.30	0	.71	4.84
Los Angeles	457	1.07	4.16	.82	.43	0	6.48	.11	.33	.33	2.28	0	.43	3.48
Lowe Observatory	3,420	*	*	*	11.10	0	11.10	*	*	*	*	*	3.76	3.76
Monrovia	....	.05	5.08	4.48	.45	.41	10.47	.02	.92	.06	1.13	1.82	0	3.95
Mount Wilson	5,850	.58	6.38	4.37	1.14	0	12.47	.36	.76	.03	4.40	.03	.30	5.88
Nenach	....	*	1.40	.90	.25	0	2.55	0	0	0	.12	0	0	0.12
Newhall	1,200	2.00	3.03	1.93	.38	0	7.34	0	0	0	2.67	0	.43	3.10
Norwalk	....	.07	2.00	1.45	.72	.25	4.49	0	.50	.10	1.80	.90	.15	3.45
Pacoima	1,570	*	4.50	3.05	.57	.15	8.27	.10	.75	.05	1.36	1.09	.40	3.75
Pasadena	825	.41	4.68	2.47	.75	0	8.31	.04	.54	0	2.58	.01	.31	3.48
Pomona	840	.05	3.50	4.85	1.05	.55	10.00	.02	.60	.35	1.10	2.22	0	4.29
Ravenna	....	0	1.25	1.45	.57	.20	3.47	0	0	0	.35	.45	0	0.80
San Fernando	975	*	3.97	2.73	.68	0	7.38	.16	0	.05	1.62	.61	0	2.44
San Gabriel	....	*	5.30	2.82	.95	0	9.07	0	0	0	2.35	0	0	2.35
San Pedro	62	1.00	.40	.50	0	0	1.90	0	.40	0	1.60	.60	0	2.60
Santa Monica	110	*	*	5.82	.63	0	6.45	0	.63	0	2.85	0	.50	3.98
Sierra Madre	1,400	*	5.50	3.30	.94	0	9.74	*	1.20	.10	2.50	.12	.35	4.27
Tropico	....	*	2.50	.80	.16	0	3.46	.50	0	1.06	1.40	0	.38	3.34
Valyermo	3,750	.20	2.77	1.72	.39	.23	5.31	0	0	0	.58	0	T.	0.58
Walnut	149	*	*	6.00	.75	0	6.75	*	.50	*	*	3.00	.50	4.00
Wilmington	....	.60	1.90	.80	.65	0	2.95	.70	.60	0	2.20	.70	.05	4.25
Daily means[1]	....	.34	.82	2.94	.87	.11	5.08	.11	.45	.19	1.80	.72	.24	3.51

TABLE 13.—*Daily precipitation in Orange County, Cal., January 16–20 and 24–29, 1916.*

Stations.	Altitude.	January—					Total.	January—						Total.
		16	17	18	19	20		24	25	26	27	28	29	
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Buena Park	....	0.09	2.30	1.67	0.99	0	5.05	0	0.32	0	1.68	0.77	0.90	3.67
Old Ranch	....	.10	1.68	.87	.96	.32	3.93	0	.48	.09	2.15	1.50	.02	4.24
Orange	....	.17	2.42	1.57	.89	.42	5.47	0	.42	.22	2.01	1.32	.04	4.01
Santa Ana	2,850	.14	1.78	1.18	.51	.57	4.18	0	.32	.28	1.62	1.74	0	3.96
Tustin (near)	123	.12	1.75	1.06	.78	.38	4.09	0	.41	.26	1.41	1.68	.07	3.83
Yorba Linda	405	.52	3.52	1.17	1.17	0	6.38	0	.40	0	3.01	.04	.47	3.92
Daily means	....	.19	2.24	1.25	.88	.28	4.84	0	.39	.14	1.98	1.18	.25	3.94

* Rainfall included in the next measurement.

[1] For the purpose of forming the daily means the total amount of rain, as given for a few stations in the tables at which but a single measurement for the storm was made, was distributed proportionately among the several days on which rain fell.

TABLE 14.—*Daily precipitation in San Bernardino County, Cal., January 16–20 and 24–29, 1916.*

Stations.	Altitude.	January—					Total.	January—						Total.
		16	17	18	19	20		24	25	26	27	28	29	
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Bear Valley Dam	6,700	0	0	0	0	0	0	0	0	0	0	0	4.07	4.07
Beaumont	2,317	2.08	2.20	1.71	0.70	0	6.69	0.56	0.67	1.58	2.70	0.08	0.35	5.94
Beaumont (near)	2,558	......	5.95	2.55	.61	0.74	9.85	.53	.55	2.02	4.18	0	.63	7.91
Camp Baldy	3,850	......	......	......	......	......	......	......	......	......	......	......	......	......
Chino	714	.15	4.80	3.57	1.56	.28	10.36	.80	.27	0	1.75	2.10	.07	4.99
Converse Nursery	6,000	1.02	6.80	3.64	1.70	0	13.16	T.	1.24	T.	7.42	1.76	.57	10.99
Craftonville	......	2.20	1.70	1.00	.50	0	5.40	.50	.30	.70	1.90	0	.45	3.85
Fontana	1,325	.54	4.91	1.86	1.28	0	8.59	.06	.72	.98	2.98	0	.55	5.29
Glen Ranch	2,256	.10	7.02	12.00	1.45	1.65	22.22	0	.05	0	1.98	3.10	0	5.13
Holcomb Valley	7,800	.29	3.72	2.60	.73	0	7.34	0	0	0	1.88	.44	.75	3.07
Mill Creek	3,750	......	......	......	14.20	0	14.20	0	.85	.60	......	......	7.15	8.60
Redlands	1,352	.55	3.44	.98	.79	0	5.76	0	.42	.05	2.31	.48	.07	3.33
Rialto (near)	2,250	3.04	12.95	2.80	1.37	0	20.16	.51	1.78	1.14	5.34	0	1.05	9.82
Seven Oaks	5,000	5.60	6.10	3.40	.43	0	15.53	.25	1.00	2.25	6.45	.10	.35	10.40
San Bernardino	1,054	.80	5.29	1.18	1.20	0	8.47	0	.69	.05	3.16	.14	.53	4.57
Squirrel Inn	5,280	1.21	[1] 16.81	5.83	3.02	0	26.87	.12	.69	.60	7.05	.80	1.60	10.86
Summit	3,823	.26	2.35	2.65	.40	0	5.66	0	0	0	1.41	0	0	1.41
Daily means [2]	......	1.30	5.70	3.05	1.05	.17	11.27	.21	.58	.62	3.25	.66	.95	6.27

* Rainfall included in a subsequent measurement.

[1] The rainfall at Squirrel Inn on the 17th (16.81) is the greatest amount for one day ever recorded in California.—G. H. W.

[2] For the purpose of forming the daily means the total amount of rain, as given for a few stations in the tables at which but a single measurement for the storm was made, was distributed proportionately among the several days on which rain fell.

TABLE 15.—*Daily precipitation in Riverside County, Cal., January 16–20 and 24–29, 1916.*

Stations.	Altitude.	January—					Total.	January—						Total.
		16	17	18	19	20		24	25	26	27	28	29	
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Aguanga	1,986	0	1.30	3.00	3.80	1.31	9.41	0	0	0	5.00	2.00	0.05	7.05
Cabazon	......	0.20	4.20	4.60	2.10	2.30	13.40	0	0	0.50	0.10	0	0	0.60
Cahuilla	3,800	2.00	2.00	2.25	.50	0	6.75	0	1.50	1.50	1.50	0.25	.60	5.35
Corona	615	.78	4.30	1.96	.87	T.	7.91	0.03	.36	.01	5.00	.25	.46	6.11
El Casco	......	*	3.00	1.25	1.20	0.20	5.65	0	.36	.37	1.15	.08	.43	2.39
Elsinore	1,300	3.43	2.30	1.40	.45	0	7.58	.25	.26	1.40	3.40	.02	.21	5.54
Riverside	851	2.26	1.15	.61	.51	0	4.53	.28	.43	.65	1.67	.03	.47	3.53
San Jacinto	1,560	1.10	2.78	.96	.82	0	5.66	0	.55	0	2.17	.46	.11	3.29
Daily means	......	1.35	2.50	2.00	1.28	.48	7.61	.07	.43	.55	2.50	.39	.29	4.23

* Rainfall included in a subsequent measurement.

TABLE 16.—*Daily precipitation in San Diego County, Cal., January 16–20 and 24–29, 1916.*

Stations.	Altitude.	January—					Total.	January—						Total.
		16	17	18	19	20		24	25	26	27	28	29	
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Bonita	110	0.50	1.48	2.16	0.58	0.41	5.13	*	0.04	0.14	1.26	2.10	0.43	3.97
Campo	2,543	4.75	2.23	1.20	1.23	0	9.41	0	0	.55	1.83	4.35	.10	6.83
Cuyamaca	4,677	3.35	5.83	5.27	1.59	0	16.04	0.23	1.63	1.53	8.54	1.30	1.12	14.35
El Cajon	482	1.86	4.41	1.24	.60	0	8.11	0	0.26	0.05	5.60	0.74	0.10	6.75
Escondido	710	2.00	4.85	1.95	1.06	0	9.86	0	.71	.08	5.53	.58	.50	7.40
Julian	4,222	.95	5.95	6.49	1.73	1.36	16.48	.06	.19	1.31	3.31	7.68	.35	12.90
La Jolla	2,715	2.52	7.42	4.00	1.43	T.	15.37	.10	.57	.52	5.75	1.38	.22	8.54
Mesa Grande	3,350	3.26	8.08	3.99	.10	0	15.43	.17	1.19	.34	8.55	1.63	.33	12.21
Nellie	5,350	3.52	11.24	6.00	1.85	T.	22.61	.19	1.85	.97	10.16	2.27	.85	16.29
Oak Grove	2,751	1.20	5.55	2.80	1.60	.10	11.25	T.	T.	0	7.80	1.20	.18	9.18
Oceanside	60	1.80	1.23	1.20	.26	0	4.49	.54	.08	2.02	1.60	.06	.31	4.61
Point Loma	302	0.37	.80	2.10	.93	.70	4.90	.01	.15	.14	2.14	1.27	.03	3.74
San Diego	93	.04	1.96	1.72	2.79	1.21	7.72	7.33	1.27	3.13	1.71	2.34	.69	16.47
Warner Springs	3,165	2.25	5.08	2.30	1.06	0	10.69	.01	.15	.14	4.42	.77	.26	5.75
Daily means	......	2.03	4.72	3.03	1.20	.27	11.25	.62	.58	.78	4.87	1.98	.39	9.22

* Rainfall included in a subsequent measurement.

TABLE 17.—*Daily precipitation in Arizona, January 15–21 and 25–30, 1916.*

Stations.	Altitude.	January— 15	16	17	18	19	20	21	Total.	January— 25	26	27	28	29	30	Total.
Gila Watershed.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches..
Alamo Ranger Station	3,155	0.75	1.02	0.80	0.77	0.38	0.20	0.03	3.95	0	0.49	0.28	0.55	0	0.08	1.40
Ashdale Ranger Station	3,500	.92	.99	1.84	1.42	1.20	.07	.12	6.56	T.	.26	1.31	2.35	T.	.09	4.01
Ashfork	5,229	.16	.30	.30	.60	.40	0	0	1.76	0.10	.30	.20	.20	0	.15	.95
Aztec	492	.55	.08	.03	.27	0	0	0	.93	0	0	12	.08	.03	0	.23
Bald Hill ranch	4,600	*	*	*	*	*	3.46	0	3.46	T.	T.	.69	.72	.15	0	1.56
Baseline Ranger Station	4,481	.62	.70	1.27	1.14	.76	.46	0	4.95	0	.27	.32	31	0	0	.90
Benson	3,523	0	.15	.16	.16	1.72	.26	0	2.45	0	0	0	T.	0	0	T.
Bisbee	5,350	0	0	0	0	1.68	1.45	.05	3.18	0	0	0	0	.14	0	.14
Blue	6,500	.25	.62	.33	.24	1.81	.41	0	3.66	.28	.25	.06	.49	0	.05	1.13
Bowie	3,756	0	T.	0	0	*	2.20	0	2.20	0	0	0	0	0	0	0
Buckeye	980	.98	.36	.21	.45	0	.02	0	2.02	0	0	.15	.13	.04	0	.32
Canille	5,225	.07	.06	0	0	.88	1.32	0	2.33	0	0	0	.05	.06	.01	.12
Carr's ranch	5,410	1.12	1.45	2.18	2.25	.88	.30	.28	8.46	T.	1.35	1.80	2.81	.05	.26	6.27
Casa Grande	1,422	.35	.44	.13	.24	.13	.28	.13	1.70	0	0	.09	.39	0	.09	.57
Cedar Glade	4,610	.16	.69	.55	.60	.41	0	0	2.41	.81	0	.93	.40	0	.10	2.24
Chandler	1,213	*	*	*	1.75	0	.14	0	1.89	0	T.	.05	.09	0	.06	.20
Childs	2,650	.65	1.95	0	1.33	.96	0	0	4.89	0	.22	1.56	1.48	0	.22	3.48
Clifton	3,584	.22	.42	.35	.20	1.38	.72	.10	3.39	.02	.07	0	.05	0	0	.14
Cline	2,300	1.29	1.25	1.63	1.61	.98	.26	.33	7.35	0	.30	1.04	1.80	0	.15	3.29
Cornville	3,300	.19	.40	.55	.47	.17	0	.13	1.91	0	.35	.79	.20	0	.05	1.39
Douglas	3,930	T.	T.	0	0	.56	2.39	.09	3.04	0	0	0	0	.08	0	.08
Dudleyville	2,204	.45	.49	.25	.60	1.86	.55	.18	4.38	.02	.02	.08	.13	.16	.08	.49
Elgin (near)	4,900	0	T.	T.	.02	.10	3.25	.14	3.51	0	T.	T.	.14	T.	T.	.14
Fairbank		0	T.	0	T.	1.39	1.62	0	3.01	0	0	0	0	0	T.	T.
Florence	1,493	.36	.25	.21	.41	0	.41	.11	1.75	0	0	.14	.54	0	0	.68
Fort Apache	5,200	.41	.94	.79	.71	2.51	.18	.11	5.65	.02	.48	.27	1.66	.07	.01	2.54
Fort Huachuca	5,100	0	0	0	0	0	2.00	0	2.00	0	0	0	0	0	0	0
Gila Bend	737	0	.82	0	.42	.04	.22	0	1.50	0	0	0	.81	0	0	.81
Gisela	2,300	.75	.69	1.20	1.20	.27	.05	.02	4.18	0	.27	0	1.44	0	.04	1.75
Glendale	1,160	.25	1.24	.62	.46	.10	.01	.01	2.69	0	0	.11	.26	0	0	.37
Globe	3,625	.75	1.19	.72	.69	.94	.24	.05	4.58	0	.17	.20	.75	T.	.09	1.21
Gould's ranch	1,195	.45	.90	.35	.25	.05	.05	0	2.05	0	0	0	.35	0	.09	.44
Granite Reef Dam	1,325	.42	1.06	.67	.46	.75	.30	.19	3.85	0	.08	.15	.39	0	.11	.73
Hackberry Ranger Station	2,422	1.92	1.90	2.00	1.91	1.07	.10	.22	9.12	0	.30	1.04	1.80	0	.15	3.29
Henry's camp	6,600	.51	1.06	.86	.96	.83	.85	.06	5.13	.09	.94	0	0	0	23	1.26
Hereford		0	0	0	0	1.40	.80	0	2.20	0	0	0	0	0	0	0
Higley	1,322	.20	.96	.46	.37	.43	0	.28	2.70	T.	0	.04	.03	.15	0	.22
Honeymoon	5,440	.65	.95	.70	.60	1.70	.40	0	5.00	.11	.67	.28	.76	.03	.06	1.91
Intake	2,230	*	*	3.10	*	.85	*	.32	4.27	.19	0	*	.59	.17	0	.95
Jerome	4,743	.43	.70	.82	1.12	.64	.15	0	3.86	.06	.69	1.03	1.00	0	0	2.78
Johnson Wash	4,850	*	*	*	*	4.60	0	0	4.60	*	*	*	*	2.40	0	2.40
Klondyke	3,225	.35	.59	.57	1.73	1.34	.34	.02	4.94	.15	.02	.02	.45	.15	.06	.85
Lewis Springs		.09	0	0	0	1.08	.40	0	1.57	0	0	0	0	0	0	0
McNeal	4,150	0	0	0	0	2.48	1.30	0	3.78	.04	0	0	0	0	0	.04
Maricopa	1,180	.25	.32	.43	.17	0	.32	0	1.49	0	0	0	.10	0	.04	.14
Marinette	1,150	.24	1.18	.70	.40	.14	0	0	2.66	0	0	.15	.34	0	0	.49
Mesa	1,244	.50	.87	.64	.34	.28	.04	0	2.67	0	T.	.07	.32	0	.07	.46
Miami	3,603	.33	1.57	1.18	.80	1.09	.03	.36	5.36	0	.54	.18	1.59	.53	.02	2.86
Mohawk	538	.10	0	0	0	.32	.11	.06	.59	0	0	.13	0	0	.08	.21
Naco		0	0	0	T.	1.21	1.50	0	2.71	0	0	0	T.	.07	0	.07
Natural Bridge	4,990	.98	.70	2.30	1.65	.40	.11	0	6.14	0	.50	1.30	.45	0	.28	2.53
Nogales	3,830	T.	T.	0	.55	3.81	.36	0	4.72	0	0	0	.01	0	.03	.04
Oracle	4,502	.75	1.10	.28	.50	3.41	.28	0	6.32	0	.20	0	1.30	.07	.55	2.12
Osborn		0	0	0	T.	1.23	.98	0	2.21	0	0	0	.07	0	.12	.19
Paradise Valley		.66	.90	.69	.30	.45	.01	0	3.01	0	.01	.06	.40	.05	0	.52
Payson	5,550	.33	0	1.25	1.16	.35	.17	0	3.26	0	.44	1.36	.65	0	.11	2.56
Phoenix	1,092	.29	1.05	.19	.32	T.	.02	0	1.87	T.	0	.08	.05	0	.07	.20
Pinal Ranch	4,520	2.36	2.25	2.00	0	.45	0	0	7.06	.44	2.22	1.26	0	0	.46	4.38
Prescott	5,320	.06	.85	1.22	1.60	0.25	T.	.07	4.05	.02	.35	1.25	1.28	0	.19	3.09
Do. (Dry Farm)	5,008	.06	.50	.75	.52	.48	.05	.10	2.46	T.	.24	.85	.62	.04	0	1.75
Rice	2,540	.42	.80	.48	.38	1.50	.38	.03	3.99	0	.33	.14	.43	.08	.06	1.04
Roosevelt	2,175	.90	1.64	2.53	1.26	.54	0	.20	7.07	.03	.33	1.10	.80	0	.20	2.46
Sacaton	1,280	.48	.61	.19	.23	.34	.18	.07	2.10	0	0	.09	.27	.02	.27	.65
San Simon	3,609	0	.06	T.	.15	2.63	1.02	0	3.86	0	0	T.	0	.05	0	.05
Scottsdale	1,250	.45	1.03	.70	.44	.15	.10	0	2.87	0	0	.20	.40	0	.05	.65
Seligman	5,219	*	*	*	1.50	0	0	0	1.50	T.	0	.75	.35	0	0	1.10
Sentinel	685	.02	.58	.07	.19	.08	.23	0	1.17	0	0	.10	.03	0	0	.13
Tempe	1.165	.37	.85	.49	.40	.15	.13	.01	2.40	0	0	.08	.40	T.	.05	.53
Tempe (near)		.30	1.12	.45	.21	.41	0	.09	2.58	0	T.	.07	.09	.07	0	.23
Thatcher	2,800	.09	.41	.34	1.04	1.06	.07	0	3.01	T.	0	T.	T.	0	0	T.
Tombstone	4,550	0	1.20	0	0	3.00	0	0	4.20	0	0	0	0	0	.08	.08
Tonto Ranger Station	4,470	.60	.64	.68	.51	1.09	0	.08	3.60	0	.16	.46	2.94	0	.01	3.57
Walnut Creek Ranger Station		0	.50	.92	1.15	.63	0	T.	3.20	.15	.55	1.40	.95	0	.28	3.33
Walnut Grove	3,649	*	*	*	3.85	0	0	0	3.85	T.	*	*	5.10	0	.28	5.38
Wickenburg	2,072	0	.56	.54	1.20	0	0	0	2.30	0	0	1.67	0	0	.11	1.78
Windmill Ranch		.50	0	1.12	.79	.25	0	0	2.66	.70	0	.30	1.10	0	.60	2.70
Young		.25	2.01	1.12	1.01	2.09	.30	0	6.78	.63	.10	2.05	.20	0	0	2.98
Means*		0.38	0.67	0.61	0.61	0.85	0.37	0.05	3.54	0.05	0.18	0.40	0.55	0.03	0.08	1.29
Little Colorado Watershed.																
Flagstaff	6,907	.04	.55	1.25	1.32	.21	.02	0	3.39	.66	.60	1.81	.85	.18	.19	4.29
Fort Valley	7,500	.32	.37	1.70	.47	1.45	0	T.	4.31	0	1.20	.35	1.50	T.	.35	3.40
Greer	8,500	T.	.20	.10	.20	1.00	.30	0	1.80	T.	.27	.19	.57	0	T.	1.03
Heber	6,484	.04	.37	*	*	3.00	.27	0	3.68	.01	.50	.43	1.63	T.	.15	2.72
Holbrook	5,069	.76	.21	.14	.26	.03	T.	0	1.40	0	0	0	.14	0	0	.14
Keams Canyon	6,600	0	0	.65	.60	.30	.60	0	2.15	.60	.50	.10	.10	.20	.10	1.60
Lakeside	6,900	.23	1.02	1.03	1.00	1.70	.55	0	5.53	.15	.29	.35	1.48	.09	.04	2.40
Lakeside Ranger Station	6,900	.40	.40	.90	.70	.85	0	0	3.25	.32	.50	.50	.48	.03	.01	1.84
Leupp	4,150	0	.17	.70	0	.03	.01	0	.91	0	0	0	.01	.01	0	.02
Miles Ranger Station	6,150	T.	.45	.17	.68	.10	.13	0	1.53	T.	.05	.12	.64	T.	.02	.83
Nutrioso	7,600	.30	.50	.75	.50	1.00	1.00	0	4.05	T.	.50	.30	.30	.20	.15	1.45
Pinedale	6,500	.05	.57	.88	1.40	.84	.34	0	4.08	.02	.12	.19	1.57	.01	.09	2.00
Pinto	5,660	T.	.86	.60	.15	.05	.10	T.	1.76	0	.10	*	.85	0	0	.95
Quayle		0	1.00	1.25	1.25	.20	.20	0	3.90	.25	.10	1.00	.50	.25	T.	2.10
St. Johns	5,650	.15	.83	.69	.60	.68	.18	0	3.13	0	0	0	0	0	.20	.20
St. Michaels	6,950	0	.45	.66	.50	.25	.07	.10	2.03	T.	.90	.35	.11	.11	0	1.47
Show Low		.05	.55	.75	1.21	.63	.31	0	3.50	.01	.30	.24	.66	.04	.07	1.32
Snowflake	5,644	0	.65	.75	.63	.12	.20	0	2.35	T.	T.	0	.20	0	0	.20
Springerville	6,862	T.	.25	0	0	1.30	.06	0	1.61	0	T.	T.	.03	0	T.	.03

* For the purpose of forming the daily means, the total amount of rain, as given for a few stations at which but a single measurement was made for the storm, has been distributed proportionately among the several days on which rain fell.

TABLE 17.—*Daily precipitation in Arizona, January 15–21 and 25–30, 1916*—Continued.

Stations.	Altitude.	January— 15	16	17	18	19	20	21	Total.	January— 25	26	27	28	29	30	Total.
Little Colorado Watershed—Continued.	*Feet.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Tuba	4,500	T.	T.	0.77	0.14	0	T.	0.01	0.92	0.05	0.15	0.09	0.07	0	0.05	0.41
Willow Wash	6,400	0.05	0.47	.73	1.46	0.67	0.31	0	3.69	.06	.40	.40	1.41	0.04	.08	2.39
Winslow	4,848	0	.37	.85	0	.26	0	0	1.48	0	.01	0	.01	0	0	.02
Means*		0.11	0.47	0.72	0.62	0.62	0.21	T.	2.75	0.10	0.30	0.30	0.59	0.05	0.07	1.41
Colorado Watershed.																
Allen Lake Ranger Station	6,500	0	T.	.78	1.15	.65	0	T.	2.58	T.	T.	.76	.38	0	0	1.14
Echo Park	6,600	.23	.17	.94	.37	.40	T.	.08	2.19	.40	.64	1.19	.46	0	.30	2.99
Grand Canyon	6,866	.22	.10	.74	.48	.33	0	T.	1.87	0	.62	1.02	T.	0	.32	1.96
Kingman	3,326	0	.34	.64	.32	.13	0	0	1.43	0	0	.60	.11	0	.24	.95
Moccasin	4,500	.38	0	.58	.44	.19	0	0	1.59	.25	.60	.04	.01	.01	.03	.94
Parker	353	0	.40	.58	.62	.55	.04	0	2.19	0	0	.30	.54	0	0	.84
Supai	3,200	0	.32	.04	.38	0	0	0	.74	.19	0	.52	0	0	.11	.82
Williams	6,750	0	.23	1.36	1.54	.81	.27	0	4.21	0	.42	.63	.21	0	.34	1.60
Yuma	141	.11	.18	.02	.07	.10	0	0	.48	0	0	.03	0	T.	0	.03
Means*		0.10	0.19	0.63	0.60	0.35	0.03	0.01	1.91	0.09	0.25	0.57	0.19	T.	0.15	1.25
Desert Watershed.																
Ajo	1,805	.03	.13	.05	.30	.16	T.	0	.67	0	.02	.10	.56	.18	.01	.87
Bonita	4,916	0	.90	0	0	2.00	.85	0	3.75	.15	0	0	0	0	.10	.25
Cochise	4,250	.02	.02	.08	.04	1.74	.10	0	2.00	0	0	.04	0	0	0	.04
Cyclopic	4,500	0	0	1.05	.83	.05	0	0	1.93	.04	.03	.48	0	0	.20	.75
El Dorado	5,250	0	0	0	0	2.00	2.24	0	4.24	0	.05	0	0	.09	0	.14
Hackberry	3,500	0	.09	.51	.53	.05	0	0	1.18	T.	.02	.33	T.	0	.20	.55
Light		T.	.12	T.	.02	1.58	2.05	0	3.77	0	T.	0	0	0	T.	T.
Paradise	5,436	0	0	0	*	*	3.60	0	3.60	0	T.	0	0	T.	0	T.
Pearce (near)	4,400	.02	.09	T.	.15	1.30	1.69	.04	3.29	0	T.	0	.02	T.	T.	.02
Portal	5,000	0	0	0	0	2.30	0	0	2.30	.08	0	0	.01	0	.03	.12
Redrock	1,864	0	.50	.13	1.35	.55	0	0	2.53	0	0	0	.40	0	0	.40
Rosemont	4,800	0	.04	T.	.18	*	4.18	0	4.40	0	0	0	.25	0	.10	.35
Ruby		0	0	.10	0	2.51	1.25	.37	4.23	0	.05	0	.28	0	.15	.48
Salome	1,875	.24	.88	.32	.47	0	0	0	1.91	0	0	.60	.13	0	.13	.86
Truxton	3,997	0	.16	.56	.35	.30	0	0	1.37	0	.07	.70	.40	.14	0	1.31
Tucson	2,425	.05	.07	.06	.07	2.63	.51	.01	3.40	0	0	T.	.14	0	.05	.19
Willcox	4,203	0	0	.10	.12	.50	1.50	.52	2.74	0	0	0	0	.10	0	.10
Means*		0.02	0.18	0.17	0.26	1.16	0.94	0.06	2.79	0.02	0.01	0.13	0.13	0.03	0.06	0.38

* For the purpose of forming the daily means, the total amount of rain, as given for a few stations at which but a single measurement was made for the storm, has been distributed proportionately among the several days on which rain fell.

TABLE 18.—*Average daily precipitation in counties of California and Arizona, January 16–20 and 24–29, 1916.*

Counties.	Number of stations.	January— 16	17	18	19	20	Total.	January— 24	25	26	27	28	29	Total.
California.														
Ventura	4	1.56	2.58	1.32	0.22	0	5.68	0.11	0.43	0.82	1.82	0.49	0.24	3.91
Los Angeles	35	0.34	0.82	2.94	0.87	0.11	5.08	0.11	0.45	0.19	1.80	0.72	0.24	3.51
Orange	6	0.19	2.24	1.25	0.88	0.28	4.84	0	0.39	0.14	1.98	1.18	0.25	3.94
San Bernardino	16	1.30	5.70	3.05	1.05	0.17	11.27	0.21	0.58	0.62	3.25	0.66	0.95	6.27
Riverside	8	1.35	2.50	2.00	1.28	0.48	7.61	0.07	0.43	0.55	2.50	0.39	0.29	4.23
San Diego	14	2.03	4.72	3.03	1.20	0.27	11.25	0.62	0.58	0.78	4.87	1.98	0.39	9.22
Arizona.														
Gila watershed	77	0.67	0.61	0.61	0.85	0.37	[1] 3.11	T.	0.05	0.18	0.40	0.55	0.03	[1] 1.21
Little Colorado watershed	22	0.47	0.72	0.62	0.62	0.21	[2] 2.64	T.	0.10	0.30	0.30	0.59	0.05	[2] 1.34
Colorado watershed	9	0.19	0.63	0.60	0.35	0.03	[3] 1.80	T.	0.09	0.25	0.57	0.19	T.	[3] 1.10
Desert	17	0.18	0.17	0.26	1.16	0.94	[4] 2.71	T.	0.02	0.01	0.13	0.13	0.03	[4] 0.32

[1] Total for period Jan. 15–21, 3.54 inches; Jan. 25–30, 1.29 inches.
[2] Total for period Jan. 15–21, 2.75 inches; Jan. 25–30, 1.41 inches.
[3] Total for period Jan. 15–21, 1.91 inches; Jan. 25–30, 1.25 inches.
[4] Total for period Jan. 15–21, 2.79 inches; Jan. 25–30, 0.38 in[illegible].

TABLE 19.—*Average daily precipitation in the watersheds named for January 21–22 and 26–31, 1916.*

State.	Number of stations.	Watershed.	January, 1916. 21	22	Total.	January, 1916. 26	27	28	29	30	31	Total.
Kansas	21	Neosho	1.36	0	1.36	1.06	0.36	0.20	0.04	0.04	0.05	1.75
Oklahoma	28	Arkansas	0.25	2.59	2.84	0.74	1.20	0.21	0.15	0.60	0.26	3.16
Arkansas	21	White	0.56	0.33	0.89	0.17	1.49	0.68	1.11	1.24	0.89	5.58
Do	12	Arkansas	0.84	0.41	1.25	0.32	1.36	1.03	1.19	0.76	0.99	5.65
Missouri	9	White	0.59	0.34	0.93	0.38	1.53	0.74	1.39	1.84	0.39	6.27
Do	7	Osage	1.20	0.16	1.36	0.83	1.16	0.22	0.31	0.37	0.20	3.09
Do	3	Gasconade	0.06	T.	0.06	T.	1.13	0.42	1.19	2.04	0.17	4.95
Do	1	Meremec	0.11	0	0.11	0.01	0.95	1.22	0.76	3.05	0.28	6.27
Iowa	114	Mississippi				0.40	0.35	0.14	0.22	0.07	0.05	1.23
Illinois	13	....do.[1]	0.93	T.	0.93	0.05	0.92	T.	0.43	0.19	0.16	1.75
Do	19	....do.[2]	0.14	0.05	0.19	T.	0.63	0.60	1.06	2.24	0.65	5.18
Do	15	Illinois	1.56	0.01	1.07	0.05	0.37	0.14	0.49	0.56	0.13	1.74
Do	6	Ohio	0.22	0.26	0.48	0.01	0.42	1.25	2.08	1.08	1.81	6.65
Do	14	Wabash	0.19	0.12	0.31	T.	0.29	0.28	0.65	2.16	1.09	4.47
Indiana	11	West Fork White	0.11	0.18	0.29	T.	0.20	0.35	0.76	1.84	1.41	4.56
Do	11	East Fork White	0.09	0.36	0.45	T.	0.30	0.28	0.69	1.38	1.02	3.67
Do	1	White	0.12	0.48	0.60	T.	0.02	0.36	0.58	2.62	2.12	5.70
Kentucky	8	Green	0.13	0.85	0.98	T.	0.20	0.66	0.48	0.03	1.06	2.43
Do	7	Ohio	0.15	0.70	0.85	0.01	0.25	0.54	1.80	0.75	1.15	4.50
Ohio	120	....do				0.01	0.08	0.09	0.39	0.62	0.44	1.63
West Virginia	53	....do				0.04	0.07	0.06	0.40	0.47	0.17	1.21
Pennsylvania	40	....do				T.	0.01	0.02	0.03	0.49	0.42	0.97
Tennessee	16	Cumberland				T.	0.05	0.13	0.22	T.	0.48	0.88

[1] Above the Illinois. [2] Below the Illinois.

TABLE 20.—*Precipitation of 2 inches and over in 24 hours, Jan. 21–31, 1916, at the places and on the dates named.*

Station.	Amount.	Date.
ARIZONA.		
Watershed of Gila and tributaries, Jan. 15–28.		
	Inches.	
Pinal ranch	2.36	15
Childs	1.95	16
Pinal ranch	2.25	16
Young	2.01	16
Carr's ranch	2.18	17
Natural Bridge	2.30	17
Pinal ranch	2.00	17
Hackberry Ranger Station	2.00	17
Carr's ranch	2.28	18
Bonita	2.00	19
El Dorado	2.00	19
Fort Apache	2.51	19
McNeal	2.48	19
Nogales	3.81	19
Oracle	3.41	19
Portal	2.30	19
Ruby	2.51	19
San Simon	2.63	19
Tombstone	3.00	19
Tucson	2.63	19
Young	2.09	19
Douglas	2.39	20
El Dorado	2.00	20
Elgin (near)	3.25	20
Fort Huachuca	2.00	20
Pinal ranch	2.22	26
Young	2.05	27
Ashdale	2.35	28
Carr's ranch	2.81	28
Tonto Ranger station	2.94	28
Walnut Grove	*5.10	28
OKLAHOMA.		
Arkansas watershed.		
Bacone	3.38	21
Calvin	3.40	21
Claremore	2.30	21
Fort Gibson	3.90	21
Muskogee	3.68	21
North Muskogee	4.12	21
Tahlequa	3.73	21
Tulsa	2.20	21
Vinita	2.00	21
Wagoner	3.00	21
Vinita	1.98	26
Wagoner	2.00	26
Webbers Falls	2.50	26
Fort Gibson	2.36	27
North Muskogee	2.07	27
Tahlequa	1.95	27
Webbers Falls	2.12	27
Wyandotte	2.00	27
Canadian watershed.		
Ada	6.50	21
Bristow	2.00	21
Chandler	2.80	21
Eufaula	2.68	21
Holdenville	5.72	21
Okemah	3.20	21
Okmulgee	2.50	21
McAlester	6.81	27
Red watershed.		
Durant	3.82	27
ARKANSAS.		
Arkansas watershed.		
Dumas	2.55	21
Lake Farm	2.30	21
Pond	2.52	21
Pine Bluff	1.97	22
Bentonville	3.30	26
Fort Smith	2.50	26
Pond	2.00	26
Booneville	2.10	27
Lake Farm	2.60	27
Lutherville	2.18	27
Rogers	3.32	27
Bee Branch	2.00	28
Lake Farm	2.10	28
Little Rock	2.43	28
Stuttgart	1.96	28
England	2.50	29
Pine Bluff	3.62	29
Pond	2.02	30
Rogers	2.40	30
Dumas	2.45	31
Okay	**2.70	31
Stuttgart	1.99	31
Mississippi watershed.		
Arkansas City	2.76	22
Helena	2.87	22

Station.	Amount.	Date.
ARKANSAS—continued.		
Ouachita watershed.		
	Inches.	
Crossett	3.02	21
Fordyce	2.00	21
Huttig	2.37	21
Portland	3.55	22
El Dorado	2.15	22
Sheridan	2.20	22
Warren	2.00	22
Fordyce	4.09	28
Camden	3.70	29
Sheridan	2.70	29
Arkadelphia	2.00	30
Rison	2.47	30
Crossett	2.43	31
Fordyce	2.10	31
Huttig	3.12	31
Portland	2.05	31
Red watershed.		
Whitecliffs	2.00	27
Emerson	4.20	28
Hope	2.12	28
Lewisville	2.90	28
Emerson	2.20	31
Texarkana	2.10	31
St. Francis watershed.†		
Marked Tree	2.20	31
Wynne	2.90	31
White watershed.		
Eureka Springs	3.25	27
Fayetteville	4.10	27
Clarendon	2.20	29
Hardy	2.00	29
Mammoth Springs	2.31	29
Dodd City	2.25	30
Eureka Springs	2.82	30
Fayetteville	2.65	30
Nail	3.00	30
Brinkley	3.36	31
Georgetown	2.80	31
Jonesboro	2.10	31
MISSOURI.		
Mississippi watershed.		
Ironton	2.35	28
Marble Hill	2.00	30
Patton	2.75	30
Cairo, Ill	2.26	30
Ironton	4.65	30
St. Louis (1)	2.37	31
St. Louis (2)	2.74	31
Cape Girardeau	2.10	31
Cardwell	2.70	31
Caruthersville	2.77	31
New Madrid	3.20	31
Sikeston	2.25	31
Gasconade watershed.		
Houston	3.65	30
Black watershed.		
Goodland	3.67	30
Koshkonong	2.47	29
Meramec watershed.		
Oakfield	2.16	30
Gano	3.05	30
Rolla	2.51	30
Neosho watershed.		
Neosho	2.03	20
Dean	2.28	21
Mountain Grove	2.10	21
Dean	2.01	27
Mount Vernon	2.30	27
Neosho	2.30	27
Osage watershed.		
Clinton	2.35	20
Nevada	2.70	20
Bolivar	3.15	26
Lebanon	2.20	27
Lockwood	2.38	27
White watershed.		
Hollister	4.00	26
Springfield	2.08	26
Hollister	2.90	30
Mountain Grove	3.58	30

*Total for 3 days. ** Total for 2 days. † Two stations only in St. Francis watershed.

TABLE 20.—*Precipitation of 2 inches and over in 24 hours, Jan. 21–31, 1916, at the places and on the dates named*—Continued.

Station.	Amount.	Date.
ILLINOIS.		
Illinois watershed.	*Inches.*	
Aurora	2.10	21
Dwight	1.93	21
Henry	2.00	21
Joliet	2.08	21
La Grange	1.90	21
Morris	2.65	21
Streator	2.07	21
Macomb	**3.00	21
Carlinville	2.08	30
Decatur	2.06	30
Morrisonville	2.03	30
Ohio watershed.		
Equality	2.12	28
Anna	2.15	29
Golconda	2.02	29
McLeansboro	2.30	29
New Burnside	2.22	29
Shawneetown	2.47	29
Golconda	2.55	31
Shawneetown	2.50	31
Mississippi watershed.		
Chester	2.62	29
Du Quoin	2.35	29
Ewing	2.60	29
Grafton	2.40	30
Hillsboro	2.23	30
Greenville	2.21	30
Cairo	2.26	30
Chester	3.56	30
Mascoutah	2.35	30
Mount Vernon	2.00	30
Nashville	3.18	30
Salem	2.76	30
Sparta	4.12	30
Waterloo	2.34	30
Windsor	2.35	30
Pana	2.05	30
Wabash watershed.		
Fairfield	2.30	30
Montrose	2.77	30
Newton	2.92	30
Olney	2.83	30
Palestine	3.62	30
Sidel	2.33	30
Tuscola	2.09	30
Mount Carmel	2.35	30
Paris	2.45	31
KENTUCKY.		
Ohio watershed.		
Owensboro	2.35	29
Anchorage	2.00	29
Cloverport	2.13	29
Irvington	2.51	29

Station.	Amount.	Date.
Ohio watershed—contd.		
KENTUCKY—continued.	*Inches.*	
Louisville	2.13	29
Louisville (Cherokee)	....	29
Taylorsville	2.30	29
Shelbyville	1.96	30
Paducah	2.69	31
Green watershed.		
Franklin	2.05	31
Mississippi watershed.		
Blandville	2.40	31
INDIANA.		
Wabash watershed.		
Farmersburg	2.68	30
Rockville	2.82	30
Salamonia	2.02	30
Terre Haute	3.13	30
Vincennes	3.00	30
Do	2.00	31
White watershed.		
Decker	2.62	30
Do	2.12	31
White watershed, East Fork.		
Shelbyville	3.42	30
Shoals	2.31	30
White watershed, West Fork.		
Bloomington	2.46	30
Elliston	2.87	30
Greencastle	2.34	30
Worthington	2.42	30
Bloomington	2.34	31
Elliston	2.32	31
Ohio watershed.		
Mount Vernon	2.14	29
Rome	2.05	29
Mount Vernon	2.08	31
Whitewater watershed.		
Cambridge City	2.00	30
Richmond	2.00	30
TENNESSEE.		
Cumberland watershed.		
Dickson	2.45	31
Cedar Hill	2.45	31

SNOWFALL AT HIGH ALTITUDES, JANUARY, 1916.

The snowfall of January, 1916, particularly in California, Nevada, Arizona, New Mexico, Wyoming, Montana, Utah, and Idaho, was exceptionally heavy. Not for many years has the January snowfall in the high altitudes been so abundant. Further details are given in the monthly reports of section directors.

MEAN LAKE LEVELS DURING JANUARY, 1916.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Feb. 3, 1916.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during January, 1916:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.59	579.22	571.68	245.05
Above or below—				
Mean stage of December, 1915	−0.13	−0.29	+0.31	+0.27
Mean stage of January, 1915	+0.77	−0.22	+0.57	+0.35
Average stage for January, last 10 years	+0.62	−0.76	−0.09	−0.51
Highest recorded January stage	−0.19	−3.45	−1.87	−2.55
Lowest recorded January stage	+1.71	+0.14	+0.72	+1.25
Average relation of the January level to:				
December level	−0.3	−0.2	0.0	+0.1
February level	+0.2	0.0	+0.1	−0.2

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL ABBREVIATIONS USED IN THE INSTRUMENTAL REPORTS.

CHARACTER OF THE EARTHQUAKE.

I=noticeable.
II=conspicuous.
III=strong.
d=(terræ motus domesticus)=local earthquake (sensible or felt).
v=(terræ motus vicinus)=near-by earthquake (within 1,000 km.).
r=(terræ motus remotus)=distant earthquake (1,000 to 5,000 km. distant).
u=(terræ motus ultimus)=very distant earthquake (beyond 5,000 km.).

Examples.—I_d indicates a local earthquake of small intensity but sensible to individuals.
III_r=indicates a distant earthquake whose record shows motions of considerable amplitude.

PHASES.

P=(undæ primæ)=first preliminary tremors.
PR*n*=P waves reflected *n* times at the earth's surface.
S=(undæ secundæ)=second preliminary tremors.
SR*n*=S waves reflected *n* times at the earth's surface.
PS=transformed waves; longitudinal (P) to transversal (S) or vice versa.
L=(undæ longæ)=long waves in the principal portion.
M=(undæ maximæ)=greatest motion in the principal portion.
C=(coda)=trailers.
F=(finis)=end of sensible disturbance.

NATURE OF THE MOTION.

i=(impetus)=abrupt beginning.
e=(emersio)=gradual appearance.
T=period=twice the time of oscillation.
A=amplitude of the earth's movement, reckoned from the zero line.
E, N, or Z attached to a symbol signifies the E-W, the N-S, or the vertical component, respectively, thus:

$$\left.\begin{array}{l} A_E \text{ is the E-W component of A} \\ A_N \text{ is the N-S component of A} \\ A_Z \text{ is the vertical component of A} \end{array}\right\} \text{measured in microns } (\mu), \frac{1}{1,000} \text{ mm.}$$

INSTRUMENTAL CONSTANTS.

T_0=period of the instrument.
V =magnification of the instrument.
ϵ =damping ratio.

SEISMOLOGICAL REPORTS FOR JANUARY, 1916.

By W. J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: Weather Bureau, Washington, D. C., March 1, 1916.]

TABLE 1.—*Noninstrumental earthquake reports, January, 1916.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	H. m.		° ′	° ′			*Secs.*			
1	23 55	Claremont	34 07	117 44						F. P. Brackett.
	23 55	Corona	33 52	117 35	3	1	½	Rumbling		J. W. Garthwaite.
	23 55	Rialto	34 12	117 27	3	2	1		Rattled windows and doors	South California Edison Co.
11	5 15	Cahuilla	33 32	116 43	4	1	10	Rumbling	Windows rattled	Dr. W. L. Shawk.
16	0 41	Peachland	38 24	122 50	2	1	4			E. H. Parnell.
		INDIANA.								
7	19 45	Worthington	39 08	86 58	3	1	5			D. W. Solliday.
		NEVADA.								
18	9 00	Rebel Creek	41 39	117 45		1	2			F. Whitaker.
		NEW YORK.								
5	13 56	Caldwell	43 24	73 43	5	2				Chas. Forsell.
	13 56	Gloversville	43 05	74 21		1				(Press report.)
		OREGON.								
4	18 40	Newport	44 38	124 08	3-4	2			Dishes rattled	Wm. Matthews.
		WASHINGTON.								
2	0 52	Olympia	47 02	122 55	4	3	3		Windows rattled	S. R. Holcomb.
	0 52	Seattle	47 38	122 20	4	1	2		Doors moved	U. S. Weather Bureau.
	0 52	Silverton	48 00	121 32		1	5	Rumbling		C. M. Mackintosh.
	0 52	Sumner	47 12	122 13	4	2	3		Shook buildings	H. E. Thompson.
		PORTO RICO.								
7	15 05	Vieques	18 09	65 27	2	1	1	Faint		H. M. Pease.

TABLE 2.—*Instrumental seismological reports, January, 1916.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

Alaska. *Sitka.* *Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & V=10 & T_0=16.7 \\ N & V=10 & T_0=15.6 \end{cases}$

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		P	13 33 25	6				
		S	13 43 38	7				
		eL_N	13 52 38	26				
		M_N	14 01 30	21		30		
		M_E	14 05 28	16	185			
		C_N	14 06 00	21				
		C_E	14 09 30	17				
		F_E	14 50 00					
		F_N	15 35 00					
13		P	8 44 57	7				
		S_N	8 51 11	15				
		L_N	8 58 14	26				
		eL_E	9 06 18	26				
		M_E	9 07 28	24	12			
		M_N	9 16 10	20		4		
		C_E	9 20 00	19				
		C_N	9 34 00	18				
		F	11 06 00					

Arizona. *Tucson.* *Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & V=10 & T_0=16 \\ N & V=10 & T_0=19.6 \end{cases}$

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		L_E	14 05 35	26				No motion on N-S.
		M	14 13 50	18	50			
		C	14 25 00	17				
		F	15 57 00					
13		eL_E	7 13 48	22				
		M_E	7 24 00	17	1			
		F_E	7 34 53					
13		eL	8 55 50	4				
		M_E	9 15 35	22	6			
		M_N	9 28 39	18		1		
		F_N	10 20 49					
		F_E	10 37 23					
15		P	10 00 27	3				
		L	10 01 17					
		M_E	10 01 26	3	3			
		M_N	10 01 53	5		1		
		F	10 08 26					
24		eL_E	7 46 00	21				
		eL_N	7 48 25	28				
		M_E	7 56 55	21	1			
		M_N	7 17 15	21		2		
		F_N	8 11 47					
		F_E	8 14 41					

California. *Berkeley.* *University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton.* *Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma.* *Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

(Report for January, 1916, not received.)

California. *Santa Clara.* *University of Santa Clara.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.

(See record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver.* *Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		M	13 — —					Doubtful indications of quake.
		F	14 — —					
13								Doubtful activity here.
15								No sure record here.
16		M_N	15 — —					Visible activity but no record.
		F_N	18 — —					
22		M_E	15 20 00					Activity at hours marked and also during day.
		F_E	17 40 00					
24–27								Activity at intervals on both components.
29		M_E	10 30 —					Activity on E-W.
		F_E	15					

District of Columbia. *Washington.* *U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum, undamped. Mechanical registration).

Instrumental constants: V 110, T_0 6.4

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	II_u	P	13 39 45				5,250	
		S	13 46 41					
		L	13 53 30					
		L	13 58 23					
		L	14 12 30	60				
		L	14 16 30	32				
		L	14 23 00	24				
		F	16 35 00					
13		S	6 40 12					P indeterminable.
		L?	6 58 00					
		L	7 19 30	24				
		L	7 30 10	20				
		F	8 15 00					
13	II_u	P?	8 29 52				12,875?	
		S	8 42 44					
		L	9 01 00	48				
		L	9 14 30	60				
		L	9 20 30	30				
		L	9 29 40	30				
		L	9 36 30	20				
		F	11 15 00					
19		L	20 04 40					
		F	20 40 00					

TABLE 2.—*Instrumental seismological reports, January, 1916*—Continued.

District of Columbia. *Washington. U. S. Weather Bureau*—Contd.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 24	I_u	P?	7 06 58				8,520?	
		S	7 16 44					
		L	7 30 00	42				
		L	7 37 00	28				
		F	8 30 00					
26	I_u	P	7 49 17				7,275?	
		S?	7 58 00					
		L	8 12 30					
		F	8 30 00					
26	I_u	P	12 40 05				11,500?	
		S?	12 52 06					
		L	13 12 30	40				
		L	13 20 30	20				
		F	14 15 00					
30		L	21 24 30					
		L	21 32 30					
		F	21 50 00					
31	I_u	P	18 07 35				8,950	
		S	18 17 43					
		L	18 28 45					
		L	18 31 29	24				
		L	18 37 00	20				
		F	19 15 00					

District of Columbia. *Washington. Georgetown University.* F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil; decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants:		*V*	T_0	ε
	E	165	5.4	2.6
	N	143	5.2	3.4
	Z	*80*	*3.0*	*0*

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	III_r	eP_E	13 41 07					Microseisms present; record very doubtful. Mainka shows P later. No distinct M. Recorded on vertical.
		eP_N	13 41 13					
		S_N?	13 50 00					
		L_E	13 58 44					
		L_N	13 58 49					
		F	15 46 00					
13	III_r	e_N	7 25 16					
		e_E	7 26 03					
		L_N	7 27 18					
		L_E	7 28 20					
		F	7 56 00					
13	III_r	eP_E	8 40 18					Microseisms present. Recorded on vertical.
		eP_N	8 40 22					
		S_E	8 43 49					
		S_N	8 43 52					
		L_E	9 00 21					
		L_N	9 00 24					
		M_E	9 22 32	30	3			
		M_N?	9 22 36	30				
		M_E	9 29 04	30	6			
		M_N	9 29 52	30		5		
		M_N	9 38 02	20		5		
		M_E	9 38 47	20	5			
		F_E	10 35 00					
		F_N	10 42 00					
24	II_r	e_N	6 19 07					
		e_E	6 19 12					
		S_E?	6 24 15					
		S_N?	6 24 18					
		F	6 42 00					
24	II_r	eP_N	7 07 00					Series of long waves from $7^h 32^m$ to $7^h 55^m$. No distinct M.
		eP_E	7 07 01					
		eL	7 31 06	30				
		F	8 27 00					
31	III_r	eP_N	18 09 33					
		eP_E	18 09 39					
		S	18 20 03					
		R	18 28 20					
		L_E	18 30 25	20				No distinct maximum.
		L_N	18 33 17	20				
		F	19 39 00					

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.8

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		P	13 30 12					
		S	13 38 12					
		L	13 44 12	22				
		M	13 50 36		*17,200			
		C	15 01 24					
		F	18 37 48					
1		P	23 55 24					
2		L	0 00 48					
		M	0 02 06		*200			
		C	0 07 24					
		F	0 25 00					
2		e	2 04 00					
		M	2 06 00		*100			
		F	2 19 48					
3		e	23 22 12					
		M	23 29 00		*200			
		F	23 34 00					
11		e	11 38 30					
		L	11 43 48					
		M	11 48 00		*200			
		C	12 02 00					
		F	12 22 00					
11		e	17 02 48					
		M	17 08 48		*200			
		F	17 22 12					
13		P	6 30 00					
		S	6 39 18					
		L	6 51 18	22				
		M	7 00 00		*8,600			
		C	7 05 48					
13		P	8 32 30					
		S	8 42 00					
		L	8 52 30	23				
		M	8 58 00		*17,200			
		C	9 10 00					
		F	12 55 00					
13		L	22 20 06	22				
		M	22 27 30		*200			
		C	22 32 06					
		F	22 56 54					
18		e	14 22 48	22				
		M	14 27 30		*200			
		F	14 52 00					
19		e	11 32 06					
		M	11 37 12		*100			
		F	12 01 48					
19		P	19 14 48					
		S	19 20 18					
		L	19 25 48	20				
		M	19 28 54		*2,200			
		C	19 43 36					
		F	20 11 48					
24		e	7 23 06					Phases not well defined.
		M	7 39 54		*400			
		L	7 52 48	24				
		M	8 16 18		*600			
		C	8 27 24					
		F	9 39 00					
26		eL	8 34 06					
		M	8 46 12		*100			
		C	8 51 36					
		F	9 23 06					
26		e	12 39 24					M looks something like a local shock.
		L	12 42 42					
		M	12 44 00		*3,200			
		M	12 48 48		*2,300			
		C	12 56 30					
		F	14 04 36					

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, January, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Hawaii. *Honolulu. Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 30		P	20 29 06					
		L	20 32 42					
		M	20 35 30		*200			
		F	20 44 00					
30		P	20 51 00					
		S	20 53 54					
		L	20 57 06					
		M	20 59 12		*1,200			
		C	21 04 48					
		F	21 52 54					End confused by air currents.
31		P	18 19 30					
		S	18 24 30					
		L	18 30 00	21				
		M	18 36 42		*2,400			
		C	18 43 30					

* Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants	V	T_0	ϵ
E	177	3.4	4.0
N	205	3.4	3.8

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		P	13 39 49					E-W record lost.
		P	13 45 53	2-3				
		S	13 49 14					
		S?	13 55 21					
		S or L	13 59 25					
		L	14 07 33	40-45				
		M	14 24 45	15-20		12		
		F	15 48 00					
13		P	6 36 56					
		P_N?	6 38 54					
		P_E?	6 38 59					
		S	6 48 56					
		S_N or L	6 55 20					
		M_N	7 09 26					
		F_N	7 45 00					
13		P_E?	8 40 04					
		P_N?	8 40 55					
		S_E?	8 46 26					
		S_N?	8 46 33					
		L_N?	8 57 46					
		L_E	8 57 56					
		M_E	9 22 56	24-25	9			
		M_N	9 27 41	23-24		4		
		F	10 45 00					

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants	V	T_0
E	10	31
N	10	29

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		P_E	13 46 32					
		S_E	13 51 10					
		S_N	13 51 29	12				
		L_N	13 58 16	36				
		L_E	13 58 34	42				
		M_N	14 26 56	20		25		
		M_E	14 35 10	18	15			
		C	14 43 00	17				
		F	16 05 00					
13		eL_E	7 29 00	19				Phases very uncertain.
		eL_N	7 30 16	19				
		M_E	7 35 00	20	2			
		M_N	7 38 00	20		2		
		F_E	7 43 00					
		F_N	7 55 00					
13		P_E	8 44 11					
		P_N	8 44 20					
		L_E	9 00 34	40				
		L_N	9 01 26	44				
		M	9 31 19	25	12	16		
		C	9 42 00	20				
		F	10 35 00					
24		eL_N	7 31 00	40				Phases uncertain.
		M_E	7 43 00	17	3			
		M_N	7 48 00	17		2		
		C	7 57 00	17				
		F	8 14 00					

Massachusetts. *Cambridge. Harvard University* Seismographic Station. J. B. Woodworth.

Lat., 42° 22′ 36″ N.: long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instrument: Two Bosch-Omori, 100 kg., horizontal pendulums (mechanical registration).

Instrumental constants	V	T_0	ϵ:1
E	80	23	0
N	50	25	4:1

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		*O*?	*13 24 55*				9,800?	Ottawa makes distance 13,000 Km. i may be PR. E-W records were changed between 13h 46m and 13h 50m; N-S between 13h 54m and 14h 06m. Time on E-W interpolated from hour marks after 13h 50m because of failure of minute ticks. E-W stylus left drum at 14h 27m 20s, returning at 14h 45m 40s.
		i	13 41 30					
		S_N	13 48 26	6				
		eL_E?	13 58 30					
		L_E	14 10 10	44				
		L_N	14 10 12					
		M_E	14 27 20	24				
		C_E	14 52 00					
		F	16 10 00					
6		M_N	3 32 50	0.37		90	0	Local frost crack. Freezing after rain on snow.
		F	3 32 53					
6		M_N	11 13 12	0.44		37		Similar to preceding.
13		*O*?	*6 08 00*				12,850?	Distance and *O* from eL-S, but eS may be earlier among microseisms.
		e_N	6 40 30					
		e	6 41 21					
		e_N	6 41 28					
		e_E	6 41 53					
		S_E?	6 47 41	7				
		eL_E	7 13 11	40				
		L	7 16 02	48				
		L	7 26 06	30				
		M_E	7 34 59	20				
		L	7 38 23	18				F merged in following quake.
13		*O*?	*8 33 30*				7,020?	
		eP_E	8 43 59					
		eP_N	8 44 01					
		i_N	8 49 30	6				
		S_N	8 52 29					
		eL_N	9 01 08	48				
		eL_E	9 01 23	46				
		M_E	9 35 06	21				
		M_E	9 39 41	21				
		M_N	9 43 50	20				
		M_E	9 47 28	20				
		F	11 34 00					
19		L_E	20 05 25	20				Emerged from heavy microseisms.
		F	20 50 00					
24		*O*	*6 55 30*				8,250	
		P_E	7 07 05					N-S stylus thrown against rim of drum.
		S_E	7 16 36	14				
		eL_E	7 30 40					
		L	7 34 30	26				
		M_E	7 42 08	17	19			
		F	8 57 00					
26		*O*?	*7 19 22*				6,500?	
		S_N?	7 57 25	6				P lost in microseisms. All amplitudes very small.
		eL_N	8 06 48					
		eL_E	8 08 56	30				
		L	8 16 46	16				
		F	8 47 00					
26		*O*?	*12 26 50*				12,420?	
		eP?	12 45 02	4				P and S doubtful; difficult to read.
		S_E	12 54 37	10				
		i	12 58 10	8				
		eL_E?	13 19 39					
		L	13 23 14	24-20				L well defined.
		L	14 04 41 14 10 39	15				Sheets changed at 13h 43m.
		F	14 58 00					
30		O?	*20 57 01*				9,380?	
		eP_N	21 09 28					
		S_E	21 19 52	24				
		eL	21 24 37	28				Sinusoidal waves to F.
		L_E	21 39 08 21 55 07	18-16				No maximum.
		L_E	22 00 05	15				
		F	22 08 00					

TABLE 2.—*Instrumental seismological reports, January, 1916*—Continued.

Massachusetts. *Cambridge.* *Harvard University* Seismographic Station—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 31		O?	18 11 05				4,930	
		eP_N?	18 19 35					Masked by microseisms.
		eP_E	18 23 10	4				
		S_N	18 26 13					
		S_E?	18 28 43	8				
		eL_N	18 33 55	24				
		eL_E	18 34 59					
		L_N	18 36 05					
		L_E	18 44 30	15				
		M_E	18 45 49	20				3 waves.
		L_E	18 52 44					
		L_E	19 18 20	16-12				
		F	19 50 00					

Missouri. *St. Louis.* *St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation, 12 feet of tough clay over limestone of Mississippi System, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ϵ:1 5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	III_r	eP?	13 30 36					Times doubtful owing to microseisms and wind disturbances.
		S?	13 34 36					
		L?	13 35 48					
		F	13 46 00					
12		e_N	15 26 00					
		F	15 38 00					
12		e_N	15 43 30					
		F	15 46 18					
12		e_N	18 17 18					Microseisms strong from 18^h 38^m 12^s to 4^h 9^m on Jan. 13.
		F	18 24 00					
13		e_N	7 10 36					
		F	7 33 00					
13		e_E	7 28 30					
		F	7 33 00					
13		e_E	8 41 42					
		F	8 50 00					
13	II_u	eP_N	8 54 00				7,000	
		eP_E	9 03 30					
		L_N	9 12 42					
		L_E	9 23 12					
		F	9 48 00					
24		e_N	1 36 00					
		L_N	1 40 00					
		F	1 52 00					

New York. *Buffalo.* *Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. V 80, T_0 7, ϵ:1 5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	III_r	iP_N	13 47 15				5,000	
		eP_E	13 47 15					
		iS_N	13 53 15					
		eS_E	13 53 30					
		L_N	14 12 15	40		10		
		L_E	14 15 00	35	8			
		M_N	14 20 00	30		25		
		M_E	14 21 00	25	50			
		M_E	14 29 00	30	14			
		M_N	14 31 00	25		25		
		M_E	14 32 00	24	12			
		M_N	14 37 00			12		Last maximæ followed by afterquakes.
		F_N	15 43 00					
13	III_r	eP	6 56 30					
		L_E	7 26 00					
		L_N	7 30 00					
		M_E	7 33 00	30	6			
		M_N	7 35 00					
		C_E	7 40 00					
		F_E	7 51 00					

New York. *Buffalo.* *Canisius College*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 13	III_r	eP_E	8 41 50					
		eP_N	8 42 20					
		eP_E	8 43 00					
		eP_N	8 43 10					
		L_E	8 59 00					
		L_N	9 00 00					
		M_E	9 24 10	40	9			
		M_N	9 24 20	30		6		
		M_E	9 33 00	30	11			
		M_E	9 36 00	25	5			
		M_N	9 41 30	35		9		
		C_E	9 42 00					
		F_N	9 52 00					
		F_E	10 42 00					

New York. *Fordham.* *Fordham University.* W. C. Repetti, S. J.

Lat., 40° 57′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

		V	T_0	ϵ
Instrumental constants..	E	72	7.2	1.5
	N	73	7.2	3.75

(Report for January, 1916, not received.)

Panama Canal Zone. *Balboa Heights* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants.. V 10, T_0 20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		L	14 20 10					Distance and direction unknown, No record on N-S, at work on instrument.
		M	14 24 30		150			
		F	15 02 40					
13		P_E	8 40 44				7,240	
		P_N	8 40 49					
		L_N	9 02 41					
		M_E	9 34 30		50			
		M_N	9 34 31			70		
		F_N	10 32 00					
17		P_N	12 29 12				480	Direction unknown.
		P_E	12 29 18					
		L_N	12 30 15					
		L_E	12 30 17					
		M_N	12 30 18			250		
		M_E	12 31 26		300			
		F_N	12 35 22					
		F_E	12 35 34					
24		P	19 48 35				350	Direction unknown.
		L	19 49 19					
		M_N	19 49 27			80		
		M_E	19 49 29		50			
		F_N	19 51 50					
		F_E	19 52 00					
31		P_E	18 05 30				4,830	Waves moved in N-S direction.
		P_N	18 05 36					
		S_N	18 13 00					
		S_E	18 13 05					
		L_E	18 19 30					
		L_N	18 20 26					
		M_E	18 21 40		50			
		M_N	18 23 26			150		
		F_E	18 41 00					
		F_N	18 44 00					

Porto Rico. *Vieques.* *Magnetic Observatory.* U.S. Coast and Geodetic. Survey. H. M. Pease.

Lat. 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

		V	T_0
Instrumental constants..	E	10	21.4
	N	10	21.1

(Report for January, 1916, not received.)

TABLE 2.—*Instrumental seismological reports, January, 1916*—Continued.

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.
Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants: E: V 10, T_0 15; N: V 10, T_0 16

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1	I_r	P?	13 40 20				4,640?	
		S?	13 46 43					
		L	13 58 26	45				
		L	14 13 00	40				
		L	14 21 50	26				
		L	14 25 40	20				
		F	16 20 00					
13		S	6 40 35					Phases indeterminable.
		F	6 50 60					
13		S	8 42 40					P indeterminable.
		L	9 00 47	40				
		L	9 29 15	24				
		F	11 00 60					
24	I_u	P?	7 06 56				8,420?	
		S	7 16 37					
		L	7 29 20	40				
		L	7 34 00	28				
		F	8 10 00					
31		S?	18 19 09					
		L	18 40 00	24				
		F	19 00 00					

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.
Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants.. V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		PR1	13 40 39				13,000	Time at origin=20h 40m.
		i	13 46 34					
		i	13 48 06					
		iS?	13 48 34					
		i	13 51 00					
		eL?	13 58 00	44				
		L	14 10 00	24				
		eL?	14 12 00	44				
		L	14 22 00	22				
		L	14 30 00 15 41 00	22-16				
		F	16 35 00					
13		i	6 40 48					Very distant.
		i	6 49 10					
		i	6 50 00	10				
		eL_E	7 12 00	40				
		L_E	7 14 00	40				
		L	7 16 00	40				
		L	7 27 00 7 55 00	22-16				
		F	8 20 00					
13		PR1?	8 42 38				6,600?	
		S_N?	8 48 06					
		S_E?	8 48 18					
		eL	9 00 00	44				
		L	9 08 00	28				
		L	9 18 00	38				
		L	9 30 00	20				
		L	9 40 00	18				
		L	10 03 00	18				
		L	10 30 00	20				
		F	11 05 00					
19		eL_E	20 00 42	18				
		L	20 06 00 20 38 00	18-16				
		F	20 50 00					
24		P	7 07 06	2			8,160	
		PR1	7 10 34					
		S	7 16 32					
		SR1	7 21 50					
		eL_E	7 30 18	40				
		eL_N	7 30 54	40				
		L	7 33 00	35-28				
		L	7 38 00	24				
		L	7 43 00	16				
		L	7 46 00	14				
		F	8 30 00					

Canada. *Ottawa. Dominion Astronomical Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 26		P?	7 50 14				5,600?	
		S	7 57 30					
		eL_E	8 07 30	30				
		L_N	8 12 00	26				
		L_E	8 16 00	17				
		F	8 35 00					
26		iE?	12 54 08					
		eL_N	13 14 06	40				
		L_E	13 20 00	27				
		L	13 25 00	18				
		L	13 30 00 13 40 00	16-14				
		F	14 10 00					
30		L_E	21 32 00	24				
		L_E	21 35 00 21 55 00	20-15				
		F	22 16 00					
31		P_N	18 09 57				8,710	
		S	18 19 53					
		eL_E	18 33 18	40				
		L_E	18 35 00	30				
		L	18 41 00	22-20				
		L_N	18 46 00	16				
		L_E	18 50 00	15				
		L_E	19 02 00	14				
		F	19 45 00					

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Jan. 1		P?	13 39 54					Very large disturbance.
		eS?	13 48 18					
		i	13 50 12					
		i	13 51 12		*400			
		S?	13 55 42					
		L	13 57 24					
		iL	13 58 00	36-42				
		L	14 09 42					
		L	14 18 36	12-24				
		L	14 22 18					
		L	14 26 00	18-24				
		M	14 32 48		*20,000			
		M	14 38 42		*8,000			
		M	14 41 48	18	*4,150			
		L	15 26 36					
		M	15 28 42		*1,150			Small vibrations going on when paper was changed.
11		eL	12 58 48					P not recorded.
		M	12 30 00		*150			
		F	12 43 36					
12								Marked thickening, 18h 40m 48s to 18h 47m 48s. Possibly air currents.
13		P	6 50 36					
		S	6 57 24					
		L	7 09 18					
		L	7 15 00					
		iL	7 26 06					
		L	7 32 12					
		M	7 39 54	18-30	*3,250			
13		iL	9 00 12					P and S merge with trailers from preceding quake.
		L	9 33 12					
		L	9 39 12	18				
		M	9 44 18	18-24	*4,150			
		L	9 47 24					
13		iL	10 31 00	18				Trailers from preceding quake merge with P and S.
		M	10 36 18		*4,000			
		L	10 46 24					
13		L	12 07 24					
		M	12 12 30		*250			
		F?	13 31 42					
19		P	19 51 00				2,688	
		S?	19 55 18					
		iL	20 03 24					
		M	20 09 06		*800			
		F?	20 50 30					

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, January, 1916*—Concluded.

Canada. *Toronto.* *Dominion Meteorological Service*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 24		P?	7 13 42					P not well defined. There may be a minute thickening previous to P but impossible to measure.
		S	7 17 54					
		iL	7 23 30					
		L	7 25 54					
		L	7 43 54					
		M	7 46 42		*900			
		F	9 39 18					
26		L	7 59 54					P and S not recorded.
		iL	8 10 54					Waves occur from 9h 26m 12s to 9h 39m 18s; may be trailers or another quake.
		L	8 16 24					
		M	8 17 42		*100			
		F?	8 45 00					
26		P or S.	12 53 06					Phases not well defined.
		L or S.	13 00 00					
		iL	13 21 48					
		M	13 26 54		*650			
		F?	14 12 00					
30		L	21 31 48					P and S not recorded.
		L	21 34 06					
		M	21 42 36		*150			
		F	22 12 06					
31		S	18 20 12					P lost during attention to instrument.
		iL	18 31 36					
		L	18 41 36					
		M	18 44 06		*350			
		C	18 44 42					
		C	{19 33 48 19 37 48}					Gradual thickening.
		F	20 02 54					

* Trace amplitude.

Canada. *Victoria, B. C.* *Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instruments: Wiechert, vertical. Milne horizontal pendulum, North; in the meridian.

Instrumental constant.. T_0 18. Pillar deviation: 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 1		P	13 33 24					Very large disturbance.
		P	13 37 24					
		S	13 44 48					
		S	13 45 06					
		L	13 50 30					
		M	14 12 36		*15,000			
		M	14 14 36		*8,500			
		M	14 17 36		*3,650			
		L	15 42 12					
		M	15 53 18		*950			
		F	18 58 00					
11		P	11 58 54				2,440	
		S	12 02 54					
		L	12 05 54					
		M	12 07 24		*150			
		F	12 29 54					
13		P	6 43 24				6,440	
		P	6 45 12					
		S	6 51 24					
		L	7 06 54					
		L	7 08 12					
		M	7 19 06		*2,750			F merges into next quake.
13		P	8 32 54				12,250	
		S	8 45 24					
		L	9 06 24					
		M	9 27 00		*2,750			
13		iS	10 29 30					P confused with trailers from preceding quake.
		L	10 36 42					
		M	10 48 48		*650			

* Trace amplitude.

Canada. *Victoria, B. C.* *Dominion Meteorological Service*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 13		L	11 42 42					P and S lost in trailers from preceding quake.
		M	11 47 54		*150			
		F	12 11 54					
19		P?	19 40 30				1,410?	
		S	19 42 29					
		L	19 45 24					
		M	19 47 54		*750			
		F	20 22 06					
24		S	7 19 00					P uncertain.
		L	7 33 54					
		M	7 49 06		*500			
		F	8 44 48					
24		P	9 25 30					S uncertain.
		L	9 28 54					
		M	9 31 24		*100			
		F	9 40 48					
26		P	8 21 00				1,430	
		S	8 23 30					
		L	8 24 54					
		M	8 25 40		*100			
		F	8 39 48					
26		P?	12 48 54					
		S	12 52 54					
		L	13 10 30					
		M	13 16 30		*250			
		F	13 47 42					No reports received after the 29th.

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.[1]

London, Jan. 6, 1916, 4.46 p. m.

An exchange telegraph dispatch from Rome says that Prof. Maladra, Government observer at Mount Vesuvius, announces the volcano has been in active eruption since January 3. Three new craters have been opened and there are constant explosions, large stones being hurled to a height of half a mile. It is said there is no immediate danger from the eruption. (Assoc. Press.)

Petrograd, Russia, Jan. 24, 1916, 5 p. m. (via London, Jan. 24, 10 p. m.)

The seismograph in the Government observatory located 20 miles southwest of here registered an earth shock at 9 o'clock this morning. The intensity of the oscillations was estimated at double those experienced in the great Messina earthquake. The center of the disturbance was fixed at a point 1,500 miles distant. (Assoc. Press.)

London, Jan. 25, 1916.

A heavy earthquake was recorded by the West Bromwich Observatory. The shock was about 2,000 miles away. From certain indications it is said that it may have occurred in Asia Minor in the vicinity of the Black Sea. (Assoc. Press.)

San Francisco, Cal., Jan. 26, 1916.

Pumice stone, presumably from a submarine disturbance, was mixed with the waves which battered the Oceanic Steamship Co's. liner *Sierra* during a hurricane three days out from Sydney, N. S. W., according to a report made by the captain of the steamer which is in port to-day. Capt. Koughan said that a few hours before leaving Sydney, January 5, it was reported to him that seismographs there registered violent disturbances at sea. The *Sierra*, he said, must have passed over the seat of the volcanic outbreak. For hours the ship was in a sea of pumice, pieces varying in size from a marble to a hat being thrown on deck by the waves. (Assoc. Press.)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University.

SECTION VI.—BIBLIOGRAPHY.

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C. FITZHUGH TALMAN, Professor in Charge of Library.

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SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, Mar. 2, 1916.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the mean barometric pressure was above the normal in the northwest Canadian Provinces and over all districts east of the Rocky Mountains, except southern and western Texas. For all other sections it was below the normal. The positive departures were generally small, except along the Atlantic seaboard from the Carolinas to southern New England and in eastern Montana and the northwestern Canadian Provinces, where they were rather pronounced. The negative departures were quite marked in the central Plateau region, as also in the North Pacific States.

At the beginning of the month relatively low pressure prevailed throughout most sections, except in the South Atlantic States, Arizona, the southern portion of California, and the Canadian Maritime Provinces, where pressure was near or slightly above normal. A succession of rather extensive low and high pressure areas followed each other from the far West to the Atlantic coast during the first week, and after a few days, with the pressure generally near the normal in most sections east of the Rocky Mountains, another succession of low and high areas followed each other with more or less regularity across the country during the greater part of the second and third decades, the movement of these areas being at times quite rapid and again somewhat sluggish.

The pressure in the South Atlantic States was relatively high almost the entire month. For a short time near the end of the first week and again just after the middle of the month it fell to below the normal during the passage of low areas; likewise generally low pressure prevailed throughout the Pacific Coast States until near the end of the month, except for an occasional day or two, when moderate high areas moved in from the Pacific and across a portion of this section.

The month closed with high pressure in the extreme southeastern section and from the Rocky Mountain region westward, while elsewhere it was below the normal.

The distribution of the highs and lows was generally favorable for southerly and southwesterly winds in the New England, the Middle Atlantic, and northern portions of the South Atlantic States, the lower Lake region, and Ohio Valley, southeasterly and easterly in the Gulf region and over the Pacific Coast States, except the southern half of California, and westerly and northwesterly in the upper Lake region, the Missouri and upper Mississippi Valleys. Elsewhere variable winds prevailed.

TEMPERATURE.

The month opened with temperatures generally above the normal east of the Rocky Mountains, and slightly below to the west. During the following few days there was a general change to colder in the eastern districts and to warmer in the far West, the latter condition moving eastward, however, so that by the 5th moderate winter temperatures had overspread the eastern portion of the country.

Following this the most severe cold wave of the season, to date, appeared in the Northwest, the temperatures falling to $-30°$ at points in the upper Missouri Valley on the morning of the 5th. This cold wave moved rapidly eastward, but diminished in intensity, except along the Canadian border, where at points to the north of Lake Superior the temperatures were as much as $-50°$ F.

For the remainder of the first decade of the month temperature changes were comparatively slight, the weather continuing warm for the season over most southern and eastern districts and considerably colder than normal over the Northwest.

By the 10th, however, high pressure had again appeared in the Canadian Northwest, and colder weather had overspread the northern Plains region. A part of this cold wave moved rapidly eastward along the northern border, but the main area of cold extended southward over the Rocky Mountain and Plains regions, moving thence slowly eastward, but losing energy rapidly on account of warm rains along its front. Under the influence of this cold wave temperatures of $-50°$ occurred near the Montana boundary, zero temperatures extended into northern Texas, and freezing weather occurred over the west Gulf coast.

Following this cold wave temperatures remained below normal over much of the country until about the end of the second decade. The period from the 12th to the 19th was one of marked cold in the far Northwest, where the average temperatures for the period ranged from 15° to 25° below the normal, and it was nearly as persistently cold in portions of the Plains region and upper Mississippi Valley.

At the beginning of the third decade of the month there was a change to much warmer weather over central and eastern districts caused by a succession of low-pressure areas moving from the Pacific coast to the Southern Plains region and thence northeastward to the Great Lakes, in conjunction with high pressure off the southeastern States, thus causing warm southerly winds over much of the country from the Mississippi River east. During this period the temperatures were almost continuously above the average, the excesses ranging from 10 to nearly 20 degrees at points in the Gulf and Atlantic Coast States.

While this unusually warm midwinter weather prevailed in eastern districts cold weather persisted in the West and Northwest. About the 25th a high pressure area of considerable intensity appeared in the Canadian Northwest and rapid falls in temperature occurred throughout the northern Plains region. This cold area increased in severity during the following few days and by the morning of the 27th the temperatures had fallen below $-50°$ F. in northern Montana, but its progress eastward into the central valleys was delayed; persistent low pressure areas moved from the Southwest to the Lake region. During the 26th to 28th some of the lowest temperatures recorded in January were reported from points in the Great Plains and mountain regions of the West, while from the Ohio Valley and lower Lake region east

to the Atlantic some of the highest January temperatures ever known were recorded. Low pressure conditions in the Lake region gradually gave way during the last few days of the month and much colder weather overspread the northern districts to the east, and at the same time warmer weather set in over the Northwest, so that by the close of the month temperatures were approaching the normal over much of the country, although they were still high for the season over the southeastern States and correspondingly low at a few points in the southern Plateau region.

Extremes.—The month, as a whole, was marked by unusual ranges in temperature for the different portions of the country, although in individual regions the variations were not excessive. Over the more eastern and southern districts temperatures during the latter part of the month were, in many cases, the highest recorded in January, and from the 20th to the end of the month, especially over portions of the Atlantic Coast States, the temperatures were probably continuously higher than for any similar period in many years. In marked contrast to the East, almost continuous cold prevailed over the Northwest. Minimum temperatures as low as or lower than ever before recorded in January occurred in the Dakotas and Montana, and locally in the mountain districts. The lowest temperature reported during the month, $-57°$ F., occurred at Havre, Mont., where the mean daily departure was -26.8 degrees below normal.

Monthly averages.—From southern Arizona northeast to the upper Lakes and thence to the east and south, the mean temperatures were everywhere above the normal, the excesses ranging from $+6$ to $+9$ degrees over the greater part of the region. North and west of that line the mean temperatures for the month were nearly everywhere below normal, the month as a whole being the coldest of many years over the Missouri Valley, where the departures ranged from -10 to -25 degrees or more.

PRECIPITATION.

The low-pressure area over the far Southwest at the close of December moved rapidly northeastward to the Canadian Maritime Provinces during the first few days of January, accompanied by general precipitation, mostly rains, over all districts east of the Rocky Mountains, except the Southeastern States. By the 3d a high-pressure area of great magnitude had covered the country from the Rockies to the Appalachian Mountains, and fair weather obtained in those districts, but at the same time a storm of marked character was moving inland over the north Pacific coast, and precipitation had set in over that region and the northern plateau. During the following day or two this storm moved eastward over northern districts with attendant unsettled weather.

Near the close of the first decade a low-pressure area of great intensity and extent overspread the western portion of the country, and from the 10th to the 13th two well-defined storm areas moved thence eastward, the one passing over the northern border States and the other moving northeastward from New Mexico. During this period precipitation was general over nearly all sections of the country, with heavy rainfall in the lower Ohio and middle Mississippi valleys. A day or so of generally fair weather followed this rain period, but by the morning of the 16th unsettled weather was again the rule, although precipitation was generally light in most districts.

About the 17th a storm of marked character moved inland over southern California, and heavy rains were experienced in that locality. During the succeeding day or two the storm moved slowly eastward over Nevada and Utah, with heavy snowfall at the higher elevations. Excessive rains continued in southern California and adjoining regions, where considerable damage resulted from flood conditions. During the first few days of the third decade the storm area moved eastward, reaching the Canadian Maritime Provinces about the 23d, resulting in general precipitation over the eastern half of the country, the rainfall being unusually heavy in portions of the Lake region, the southern Plains States, the central Mississippi and lower Ohio valleys, and resulting in disastrous floods in portions of northern Illinois. The rainfall was likewise heavy in portions of the Gulf States.

From the 23d to the 25th generally fair weather was the rule in most sections of the country, but about the latter date a low area again appeared in the far Southwest, with a trough-like extension over the great central valleys between two extensive areas of high pressure, one overlying the Atlantic Coast States and adjacent ocean and the other occupying the northwestern districts. During the remainder of the month these high areas persisted in their relative positions, while low-pressure areas followed one another northeastward in succession between them. These pressure distributions marked the last week of the month, with generally cloudy weather and much precipitation, the rainfall being especially heavy in the middle Mississippi and lower portions of the Ohio and Missouri Valleys, where some loss of life and much property damage resulted from severe floods. In the meantime heavy rains had continued in the far Southwest, especially in southern California, which again caused high waters, and much loss of life and property damage occurred in connection with the breaking of a large reservoir in the mountains near San Diego.

The distribution of the precipitation for the month, as a whole, is shown on Chart V. The feature of this distribution is the heavy rainfall in California and over the districts to the south of the Great Lakes from the eastern portion of the Plains region to the Appalachian Mountains. The monthly totals for a considerable portion of this latter region range 8 to 12 inches or higher. They are even greater at the lower elevations of California, where some points had as much as 18 inches of rain during the month. In the Rocky Mountain and Plateau districts the amounts were considerably above the normal, as a rule. In most of the Plains States the precipitation was near the normal, but in the Atlantic coast districts less than the usual amount for the month occurred.

Precipitation accompanying the floods of the month is discussed in some detail on pages 28–38 and illustrated by the map forming A. J. H. figure 2 (XLIV-11).

Snowfall.—The snowfall in all sections east of the Rocky Mountains was generally light, except in Minnesota and the Dakotas, where it was above the normal, and some heavy falls occurred toward the end of the month. In the far western mountains unusually heavy falls occurred in most sections, especially in the northern districts of California, and large quantities of snow appeared to be stored in many of the higher mountain regions, with good prospects of a plentiful supply of water for the coming growing season.

GENERAL SUMMARY.

Over the districts east of the Mississippi the weather was favorable for outdoor occupations, and while the snowfall was generally light, leaving the winter grains and grasses mostly uncovered, they were not subjected to much severe freezing and were generally reported in

good condition. The soil was largely free of frost, and plowing and other farm work was possible for considerable periods.

In the southern trucking regions east of the Mississippi winter crops made good progress on account of the general warmth, and much outdoor work was accomplished.

In Florida citrus and other fruit trees were beginning to bloom, and farther north the buds were being rapidly forced by the continued warm weather.

West of the Mississippi the precipitation was generally heavier than usual, snow and ice covered the ground during much of the month, and there was some apprehension that injury might result to wheat and other winter grains therefrom. Severe cold near the middle of the month extended to the Texas coast, killing much tender vegetation in the trucking regions of that State. In the more northern portions, and generally in the mountains, the snow was heavy and much feeding of stock was necessary.

Some losses and much suffering resulted from the severe cold and long-continued snow covering. In the far Northwest the snow covering greatly benefited the winter wheat, but it necessitated much feeding of stock and greatly interfered with outdoor occupations.

Average accumulated departures for January, 1916.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.		Ins.	Ins.		0-10.		Perct.	Perct.
New England	29.2	+ 4.8	......	1.48	−2.00	......	6.3	+0.4	75	− 1
Middle Atlantic	38.0	+ 6.4	......	1.70	−1.50	......	6.5	+0.7	72	− 4
South Atlantic	52.8	+ 7.6	......	1.62	−2.30	......	5.9	+0.6	81	+ 4
Florida Peninsula	70.9	+ 6.4	......	1.03	−1.70	......	4.0	+0.8	79	− 2
East Gulf	54.8	+ 7.5	......	3.67	−1.30	......	6.5	+0.8	81	+ 3
West Gulf	51.0	+ 4.9	......	4.81	+1.80	......	7.8	+2.5	82	+ 6
Ohio Valley and Tennessee	39.9	+ 6.7	......	6.11	+2.30	......	7.1	+0.7	78	+ 1
Lower Lakes	31.4	+ 7.1	......	2.96	+0.30	......	7.6	+0.2	78	− 3
Upper Lakes	21.6	+ 3.3	......	3.27	+1.20	......	7.7	+0.8	82	− 1
North Dakota	−5.9	−10.0	......	1.04	+0.40	......	5.7	+0.8	87	+ 7
Upper Mississippi Valley	24.4	+ 2.8	......	4.45	+2.80	......	6.6	+1.2	81	+ 3
Missouri Valley	18.0	− 3.1	......	3.34	−2.40	......	5.9	+0.9	82	+ 7
Northern slope	5.7	−13.3	......	1.34	+0.50	......	5.6	+0.5	76	+ 6
Middle slope	26.0	− 3.1	......	1.48	+0.80	......	6.0	+1.9	76	+ 9
Southern slope	44.5	+ 3.0	......	0.45	−0.20	......	6.0	+1.6	64	− 2
Southern Plateau	39.4	− 1.3	......	3.05	+2.30	......	4.8	+1.4	62	+12
Middle Plateau	24.2	− 4.2	......	2.93	+1.90	......	7.0	+1.9	80	+10
Northern Plateau	19.9	− 8.9	......	1.92	+0.30	......	7.7	+1.0	78	− 2
North Pacific	31.9	− 7.5	......	5.74	−1.00	......	7.7	+0.2	79	− 6
Middle Pacific	43.2	− 4.1	......	10.92	+6.20	......	7.8	+2.6	86	+ 5
South Pacific	49.0	− 1.8	......	11.06	+8.30	......	6.8	+2.3	82	+10

WEATHER CONDITIONS ON THE NORTH ATLANTIC DURING JANUARY, 1915.

The data presented are for January, 1915, and comparison and study of the same should be in connection with those appearing in the Review for that month. Chart IX (XLIV-9) shows for January, 1915, the averages of pressure, temperature, and the prevailing direction of the wind at Greenwich mean noon, together with the locations and courses of the more severe storms of the month.

For the month as a whole the distribution of the atmospheric pressure over the greater part of the ocean was not far from the normal. On the Meteorological Chart of the North Atlantic for January, showing the normal conditions for that month, a high area surrounded by an isobar of 30.2 inches is central near latitude 28°, longitude 40°, while there is a second high off the coast of Portugal and North Africa, extending as far West as the Madeira Islands. For January, 1915, a high of normal intensity was central near latitude 35°, longitude 26°, while a secondary high with a crest of 30.1 inches extended from the fifty-eighth to ninety-fifth meridians and the thirtieth to forty-seventh parallels. The Icelandic low was of nearly normal intensity and near its usual position, being approximately central at latitude 62°, longitude 7°W.

There was a marked decrease in the number of gales since December, and on the northern trans-Atlantic steamer routes most of them occurred in the first decade of the month. Over the ocean as a whole the number of gales was below the normal for the month of January, although there were some exceptions, as in the 5 degree square between the thirtieth and thirty-fifth parallels and the fiftieth and fifty-fifth meridians, gales were reported on 6 days, a percentage of 19, while the normal for the month is 10.

On Chart III (XLIII-3), showing tracks of low areas for January, 1915, a low (I on Chart IX) is shown that first appeared on the morning of December 31 in northern Saskatchewan. This moved in an approximately southeasterly direction, crossing the Great Lakes, and on the evening of January 2 was central on the Atlantic Coast about 50 miles south of Portland. On the morning of the 3d, the center had moved to latitude 45°, longitude 54°, the barometer having fallen to 28.52 inches, and the wind increased to a velocity of from 65 to 75 miles an hour. The storm log from the steamship *Minnehaha* (Brit.) shows that the lowest barometer reading recorded by that vessel during the storm was 28.46 inches, at 6 a. m. (local time) January 3, the highest velocity of the wind being 90 miles an hour. This disturbance now curved slightly toward the north, the rate of translation being rapid, and on the 4th the center was near latitude 52°, longitude 38°, the barometer having fallen slightly, and the velocity of the wind remaining practically unchanged, as several vessels in the southern quadrant of the area reported westerly winds of from 65 to 75 miles an hour, with snow and hail. The storm then moved toward the north, decreasing in its rate of movement, the pressure and force of wind remaining about the same. It then recurved to the east, and on the 6th was near latitude 55°, longitude 29°, the barometer having risen slightly, the wind retaining its high velocity. On January 7 the center was near Stornoway, Scotland, where the barometer reading was 29.16 inches. There were no reports received from vessels in the immediate vicinity of Stornoway, although near latitude 50°, longitude 20°, winds of gale force were encountered. This storm track was remarkable for the prevalence of unusually heavy winds over a long period, as from January 3 to 6, inclusive, heavy gales of from 75 to 90 miles an hour were reported continuously along the path of the low.

On Chart III (XLIII-3), a second low (II on Chart IX) is shown near Brownsville, Tex., on the morning of January 10. This moved along the coast, accompanied by moderate winds, and on the 12th was central off Hatteras, one vessel near latitude 31°, longitude 65°, reporting a southerly gale of 64 miles. The center moved only a short distance during the next 24 hours, as on the morning of the 13th it was near latitude 37°, longitude 71°, the barometer having fallen to 29 inches; heavy north, northwesterly, and westerly gales prevailing along the coast between Boston and Charleston. From this

point the rate of movement was greatly accelerated, and moving nearly due east, it was near latitude 40°, longitude 53°, on the morning of the 14th. The winds near the center of the area were moderate and fog was reported by two vessels, while in the southwest quadrant gales prevailed over a large area. The disturbance then traveled a short distance toward the southeast, and on the 15th was near latitude 39°, longitude 49°, the winds decreasing in violence and fog being encountered north of the center.

It then curved sharply to the north, being located on the 16th near latitude 46°, longitude 48°, the wind decreasing in force and the fog covering a larger area than on the two previous days. The low then turned suddenly to the south, the center on the following day being near latitude 33°, longitude 45°. The fog had disappeared and while the winds near the center remained moderate, vessels to the west of it between the fiftieth and sixtieth meridians encountered northwest gales of from 64 to 75 miles an hour. The southerly movement from the 17th to 19th was slow, and while on the 18th heavy gales were reported between the twenty-eighth and thirty-seventh parallels and the forty-fifth and fifty-third meridians, on the 19th they had decreased in force, the low beginning to fill in, as no trace of the disturbance could be seen on the 20th. This track was remarkable for its erratic course between the 14th and 19th, and also for the fact that it was accompanied by exceptionally heavy winds for the latitude.

A low (III on Chart IX) is shown that first appeared on January 10 near latitude 39°, longitude 58°. Winds of from 56 to 64 miles an hour, with hail and snow, were reported by vessels about 5 degrees southwest of the center, although the storm area was comparatively small. This disturbance moved in a northeasterly direction and on the 11th was central near latitude 45°, longitude 50°. The barometer reading was less than on the previous day, although the wind had decreased in force, and one vessel encountered fog near the center. Moving with a uniform rate of speed toward the northeast, this low was central near latitude 48°, longitude 40°, on the morning of the 12th. In the southwest quadrant of the area winds of from 48 to 56 miles were recorded, and one vessel 15 degrees south of the center encountered a northwest gale of 56 miles an hour, while other vessels in the same vicinity experienced gales of from 40 to 48 miles an hour. The movement of this disturbance between the 12th and 13th was slow, and on the latter date it was near latitude 51°, longitude 34°, the wind having decreased, while fog was prevalent over a small area. The storm now increased in its rate of movement, and on the 14th was near latitude 57°, longitude 22°, southwest winds of 56 miles an hour being reported by two vessels near its center. Continuing in a northeasterly direction, the center of this low reached a point somewhere between Iceland and the Scandinavian coast on the 15th, although as there were no vessels in the locality, it was impossible to plot its exact position.

TEMPERATURE.

The temperature of the air over the ocean as a whole was above the average, positive departures of 10 degrees occurring between the thirty-fifth and fortieth parallels and the fiftieth and sixty-fifth meridians. In the waters adjacent to the coast of Scotland the temperatures were slightly below the normal, while between the twenty-fifth and fifty-fifth parallels, east of the fifteenth meridian, the departures ranged from 0 to +4 degrees. Off the American coast, north of the thirtieth parallel, the departures ranged from +2 to +5 degrees, while at a number of Canadian and U. S. Weather Bureau stations on the Atlantic coast they were as follows:

St. Johns, Newfoundland, +2.1°; Sydney, C. B. I., +5.6°; Halifax, N. S., +3°; Eastport, +4.5°; Portland, +4.4°; Boston, +6.0°; Nantucket, +5.5°; New York, +3.9°; Washington, +2.7°; Norfolk, +1.8°; Hatteras, +2.3°; Charleston, +0.4°; Titusville, −1.8°; Miami, −0.3°; Key West, +0.7°.

FOG.

Fog was somewhat less frequent than usual over the ocean as a whole. For the 6-year period from 1901 to 1906, the maximum amount of fog occurred off the banks of Newfoundland, where for the month of January the percentage was from 30 to 35. For the month under discussion fog was observed in that locality on 7 days, a percentage of 23. For that part of the trans-Atlantic route east of the thirtieth meridian the normal percentage is from 10 to 15, while for January, 1915, it was from 3 to 7.

PRECIPITATION.

Hail occurred on 20 days during the month and snow on 19, and both hail and snow on 17. On January 21 hail was reported near latitude 27, longitude 37, which was unusual, as it is not often seen in that locality.

Maximum wind velocities, January, 1916.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi./hr.				*Mi./hr.*	
Alpena, Mich	22	52	w.	New York, N. Y.	14	60	nw.
Block Island, R. I.	3	66	nw.	Do	17	55	nw.
Do	17	56	nw.	Do	22	51	sw.
Buffalo, N. Y.	2	60	w.	Do	23	62	nw.
Do	3	56	w.	Do	28	62	nw.
Do	4	50	sw.	North Head, Wash	20	54	sw.
Do	5	60	nw.	Do	21	62	s.
Do	6	56	nw.	Do	22	94	s.
Do	10	50	w.	Do	23	60	s.
Do	13	76	w.	Pittsburgh, Pa.	13	52	n.
Do	17	56	w.	Point Reyes Light, Cal.	1	54	s.
Do	18	52	sw.	Do	2	84	s.
Do	22	60	w.	Do	8	60	s.
Do	27	60	w.	Do	9	62	nw.
Do	31	54	sw.	Do	10	68	nw.
Cheyenne, Wyo.	4	52	w.	Do	22	69	s.
Do	21	70	w.	Do	23	73	s.
Cleveland, Ohio	10	53	s.	Do	25	50	nw.
Corpus Christi, Tex.	20	50	se.	Do	27	104	nw.
Detroit, Mich	13	50	w.	Do	28	70	nw.
Duluth, Minn	12	62	nw.	Providence, R. I.	28	60	nw.
El Paso, Tex	11	58	sw.	Pueblo, Colo	9	56	w.
Erie, Pa	10	52	se.	Sacramento, Cal.	2	50	se.
Do	12	54	se.	Sandusky, Ohio	3	51	nw.
Do	13	50	se.	Do	5	53	sw.
Do	27	50	sw.	Do	22	51	sw.
Evansville, Ind.	12	50	s.	San Diego, Cal.	27	54	s.
Flagstaff, Ariz.	28	54	sw.	Sault Ste. Marie, Mich.	22	55	w.
Fresno, Cal.	27	52	sw.	Sioux City, Iowa	27	50	nw.
Grand Haven, Mich.	5	52	w.	Tatoosh Island, Wash.	2	59	e.
Grand Junction, Colo	28	51	sw.	Do	3	61	e.
Lexington, Ky.	5	52	sw.	Do	10	50	e.
Louisville, Ky.	12	52	s.	Do	11	60	e.
Marquette, Mich.	22	55	w.	Do	12	53	e.
Mount Tamalpais, Cal.	2	63	sw.	Do	14	60	ne.
Do	9	60	sw.	Do	15	75	ne.
Do	10	50	nw.	Do	16	74	ne.
Do	13	50	sw.	Do	17	66	e.
Do	14	58	sw.	Do	20	56	sw.
Do	20	51	nw.	Do	22	56	s.
Do	23	58	s.	Do	23	50	w.
Do	27	50	se.	Do	24	58	e.
Nashville, Tenn.	12	57	se.	Do	27	50	ne.
New York, N. Y.	3	67	nw.	Do	31	55	e.
Do	4	60	nw.	Toledo, Ohio	13	54	sw.
Do	5	52	sw.	Do	27	50	s.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, January, 1916.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	° F.	° F.		° F.			° F.		Ins.	Ins.		Ins.		Ins.
Alabama	52.9	+ 7.4	Wetumpka	84	29	Cullman	6	18	3.96	− 0.43	Madison	6.91	Union Springs	1.15
Arizona	43.2	0.0	Benson	79	9	Flagstaff	−25	31	4.49	+ 3.57	Carr's Ranch	15.58	Chin Lee	0.26
Arkansas	44.3	+ 3.0	Crossett	82	11	Dodd City	− 6	14	9.37	+ 5.42	Lake Farm	13.59	Junction	4.11
California	39.8	− 6.0	Calexico	75	18	Bridgeport	−36	31	15.61	+10.20	Squirrel Inn	50.29	Sterling	0.60
Colorado	21.8	− 2.3	Las Animas	84	8	Hermit	−38	31	1.75	+ 0.66	Cumbres	12.34	Rocky Ford	T.
Florida	65.4	+ 7.0	De Land	87	13	Bonifay	24	18	1.15	− 1.96	Molino	4.40	2 stations	0.00
Georgia	53.3	+ 7.0	Glennville	84	11	2 stations	10	18	1.95	− 1.87	Clayton	4.14	Augusta	0.75
Hawaii (December)	70.3	......	Makaweli, Hawaii	90	24	Volcano House, Hawaii.	47	8	12.00	......	Olokele Ditch, Kauai.	25.36	Mahukona, Hawaii	1.31
Idaho	17.6	− 6.8	Garnet	63	3	Pierson	−38	27	3.05	+ 0.64	Soldier Creek	9.82	Oakley	0.66
Illinois	30.3	+ 4.6	Equality	72	12	Dakota	−24	13	6.87	+ 4.54	Chester	12.13	Elgin	2.58
Indiana	33.9	+ 5.2	Salem	75	12	2 stations	−10	17	7.27	+ 4.28	Shelbyville	12.00	Collegeville	1.94
Iowa	17.8	− 0.1	Leon	63	1	Inwood	−34	13	2.62	+ 1.57	Mount Pleasant	6.07	Lake Park	0.85
Kansas	25.4	− 4.4	2 stations	77	4	Irene	−22	13	2.18	+ 1.45	Columbus	8.43	Plains	0.12
Kentucky	41.2	+ 5.8	Edmonton	78	30	2 stations	− 5	17†	7.27	+ 3.05	Blandville	10.02	Weeksbury	4.26
Louisiana	57.2	+ 6.4	Lafayette	87	21	2 stations	14	12†	6.83	+ 2.97	Meriden	11.40	Lawrence	1.93
Maryland and Delaware	38.1	+ 4.7	Western Port, Md	74	21	Oakland, Md	−11	8	1.74	− 1.52	Oakland, Md	4.47	Delaware City, Del	0.90
Michigan	24.4	+ 4.5	Plymouth	67	28	Watersmeet	−35	14	3.19	+ 1.19	Wasepi	5.67	Seney	1.00
Minnesota	3.2	− 4.6	Winona	48	23	Bagley	−50	13	2.05	− 1.37	Cloquet	4.10	Reeds Landing	0.63
Mississippi	52.3	+ 5.1	Moorhead	83	11	Duck Hill	9	18	6.43	+ 1.78	Austin	10.10	Pascagoula	3.11
Missouri	31.8	+ 0.7	2 stations	72	3†	Conception	−24	13	7.36	+ 5.16	Mount Vernon	14.12	Tarkio	1.37
Montana	−0.7	−18.7	Billings	57	23	Hingham	−58	28	1.39	+ 0.47	Haugan	4.82	Renova	0.14
Nebraska	15.4	− 6.1	Hayes Center	70	9	3 stations	−32	13	0.87	+ 0.29	Bellevue	2.66	Fort Robinson	0.10
Nevada	24.1	− 5.2	Las Vegas	66	4	Millett	−31	31	3.52	+ 1.98	Marlette Lake	14.46	Thorne	0.98
New England	25.8	+ 4.7	2 stations	70	27	Van Buren, Me	−29	8	1.63	− 1.85	Somerset, Vt	4.00	Durham, N. H	0.60
New Jersey	35.1	+ 5.2	Long Branch	74	27	Culvers Lake	− 8	15	1.50	− 2.28	Tuckerton	2.96	Jersey City	0.92
New Mexico	35.8	+ 1.0	2 stations	84	4†	Dulce	−34	30†	1.94	+ 1.27	Chama	11.29	Lanark	0.06
New York	28.5	+ 5.8	3 stations	69	27	Gabriels	−27	8	2.18	− 0.78	North Lake	5.45	Haskinville	0.54
North Carolina	47.2	+ 5.9	Weldon	83	2	Banners Elk	− 3	18	2.80	− 0.97	Highlands	9.07	Wilmington	1.12
North Dakota	−6.8	−12.0	Hettinger	49	24	Goodall	−56	12	1.40	+ 0.91	Hansboro	3.50	Orange	0.20
Ohio	35.5	+ 7.0	Syracuse	75	27	Paulding	− 8	17	5.07	+ 1.91	Syracuse	8.42	Milton Dam	2.19
Oklahoma	35.9	− 2.9	Perry	80	4	Beaver	−13	13	4.80	+ 3.91	Fort Gibson	13.08	Hooker	0.31
Oregon	25.9	− 8.7	2 stations	64	23	Hermiston	−27	17†	5.24	− 0.09	Waldo	17.24	Wasco	0.72
Pennsylvania	34.2	+ 6.1	George School	76	27	Corry	−12	15	2.42	− 0.77	Indiana	5.33	Lawrenceville	0.20
Porto Rico	73.6	0.4	Guanica Centrale	95	1	Cayey	48	10	4.80	+ 1.15	Rio Grande (El Verde).	41.04	Guanica Centrale	T.
South Carolina	52.3	+ 6.7	Walterboro	81	26	Mountain Rest	10	18	1.76	− 1.61	Mountain Rest	3.82	Edgefield	0.65
South Dakota	4.3	−10.6	2 stations	60	9†	Camp Crook	−57	12	1.18	+ 0.85	Timber Lake	4.21	Vale	0.15
Tennessee	45.1	+ 6.1	2 stations	77	12†	Mountain City	− 6	18	7.54	+ 3.16	Kenton	12.10	Copperhill	1.37
Texas	51.3	+ 2.6	Fowlerton	91	1	Stratford	− 8	13	2.68	+ 1.61	Rockland	10.58	4 stations	T.
Utah	22.9	− 3.3	Scipio	62	3	East Portal	−32	.....	3.12	+ 1.78	Silver Lake	9.68	Bluff	0.29
Virginia	42.0	6.2	Callaville	76	28	Dale Enterprise	−11	8	1.97	− 1.32	Mendota	5.18	Mount Moriah Farm	0.51
Washington	20.2	−10.9	Kennewick	64	23	Snyders Ranch	−31	11	3.64	− 1.14	Forks	15.37	McConihe	0.32
West Virginia	38.8	+ 6.2	Bluefield	79	21	Marlinton	−10	8†	4.86	+ 0.97	Terra Alta	8.52	Harpers Ferry	1.70
Wisconsin	15.9	+ 1.7	2 stations	56	27	Winter	−50	14	2.52	+ 1.38	Rest Lake	5.08	Port Edwards	1.00
Wyoming	11.0	− 8.9	Chugwater	70	7	Grand Canyon	−45	17	1.20	+ 0.05	Thumb	6.43	2 stations	0.01

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations, making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes,* the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0–t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year.*

TABLE I.—*Climatological data for United States Weather Bureau stations, January, 1916.*

Districts and stations.	Elevation of instruments. Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England.							29.2	+ 4.8										75	1.48	− 2.0										6.3		
Eastport	76	67	85	30.00	30.09	+0.09	22.6	+ 2.5	48	22	31	− 6	18	14	38	21	16	75	1.86	− 2.0	15	10,467	w.	42	w.	23	6	12	13	6.5	14.2	...
Greenville	1,070	6	...	28.88	30.10	...	15.1	...	47	22	26	−16	18	4	44	...	...	...	2.35	...	11	...	...	...	...	...	...	...	...	...	16.2	12.0
Portland, Me.	103	82	117	30.03	30.16	+ .11	26.6	+ 4.6	61	26	36	− 1	15	18	41	23	16	67	2.15	− 1.7	11	7,781	sw.	48	nw.	28	13	2	16	5.7	12.2	...
Concord	288	70	79	29.84	30.17	+ .12	25.8	+ 4.6	62	26	36	− 9	18	16	36	...	...	...	1.22	− 2.1	8	4,159	nw.	28	nw.	28	12	7	12	5.4	12.1	...
Burlington	404	11	48	29.68	30.15	+ .10	23.2	+ 6.9	56	28	33	− 9	9	13	42	...	...	...	0.87	− 1.0	13	13,208	s.	48	s.	10	4	8	19	7.4	8.6	...
Northfield	876	12	60	29.17	30.16	+ .11	22.2	+ 7.1	60	28	34	−16	8	10	47	19	16	83	1.14	− 1.4	14	7,355	s.	34	sw.	5	5	7	19	7.3	11.9	T.
Boston	125	115	188	30.04	30.18	+ .13	33.0	+ 6.0	66	26	42	4	15	24	36	29	24	70	1.23	− 2.6	9	8,755	sw.	43	w.	28	9	7	15	6.0	4.8	...
Nantucket	12	14	90	30.17	30.18	+ .14	33.9	+ 1.8	53	28	40	10	15	28	23	31	28	82	2.03	− 1.4	16	13,782	sw.	47	sw.	20	7	6	18	7.3	0.5	...
Block Island	26	11	46	30.17	30.20	+ .13	34.6	+ 3.2	55	28	41	9	15	28	25	32	28	80	1.69	− 2.2	13	16,201	sw.	66	nw.	3	8	7	16	6.6	1.4	...
Narragansett Pier	...	9	...	...	...	...	32.1	+ 3.7	65	28	40	3	15	24	30	...	...	...	1.66	...	13	...	sw.	...	...	...	12	9	10	...	0.8	...
Providence	160	215	251	30.01	30.19	+ .13	32.2	+ 5.0	64	26	41	3	15	24	35	29	24	74	1.35	− 3.0	13	10,478	sw.	60	nw.	28	11	6	14	6.0	0.8	...
Hartford	159	122	140	30.02	30.21	+ .14	31.8	+ 6.3	67	27	40	5	15	24	34	28	23	71	1.16	− 2.7	9	6,619	s.	37	nw.	3	12	5	14	6.0	1.8	...
New Haven	106	117	155	30.09	30.21	+ .13	33.0	+ 5.7	65	28	41	6	15	25	34	29	24	72	1.55	− 2.4	17	7,164	s.	36	nw.	4	9	8	14	5.9	1.6	...
Middle Atlantic States.							38.0	+ 6.4										72	1.70	− 1.5										6.5		
Albany	97	102	115	30.08	30.20	+ .13	29.2	+ 6.7	56	27	37	0	9	22	34	26	21	75	1.80	− 0.8	12	7,288	s.	39	s.	10	8	5	18	6.8	0.6	T.
Binghamton	871	10	69	29.22	30.18	+ .10	31.4	+ 8.3	68	27	39	4	17	23	36	...	...	...	1.31	− 0.7	15	3,311	nw.	25	nw.	23	4	12	15	7.0	1.8	...
New York	314	414	454	29.88	30.23	+ .13	35.4	+ 5.2	66	27	43	7	15	28	31	31	24	65	1.08	− 2.7	11	15,016	sw.	67	nw.	3	7	10	14	6.5	0.7	...
Harrisburg	374	94	104	29.84	30.26	+ .16	35.5	+ 6.8	68	27	43	9	18	28	26	31	25	67	1.61	− 1.2	14	5,702	nw.	28	sw.	31	5	10	16	6.8	1.4	...
Philadelphia	117	123	190	30.13	30.26	+ .15	38.2	+ 6.4	69	27	46	9	18	31	28	34	28	68	1.50	− 1.9	15	7,736	sw.	34	nw.	6	7	11	13	6.6	2.5	...
Reading	325	81	98	29.89	30.26	...	35.8	...	71	27	43	7	18	28	30	32	26	69	1.73	− 1.8	14	5,773	nw.	29	nw.	3	7	7	17	6.8	1.6	...
Scranton	805	111	119	29.33	30.22	+ .13	33.6	+ 8.1	69	27	42	4	15	25	30	29	25	74	2.07	− 0.7	13	6,201	sw.	37	w.	3	5	10	16	6.8	4.1	...
Atlantic City	52	37	48	30.20	30.28	+ .17	37.0	+ 4.5	68	28	44	10	15	31	26	34	30	79	2.00	− 1.4	12	6,518	sw.	26	sw.	10	7	3	21	7.4	3.7	...
Cape May	18	13	49	30.26	30.29	+ .17	37.4	+ 3.3	65	28	44	12	15	31	29	...	...	...	1.62	− 1.8	15	7,412	s.	30	nw.	3	6	12	13	6.5	4.6	...
Sandy Hook	22	10	57	30.21	30.23	...	35.0	...	63	27	42	10	18	28	25	32	29	78	1.14	...	13	13,122	sw.	53	sw.	5	8	10	13	5.9	1.3	...
Trenton	190	159	183	30.02	30.24	...	35.5	...	68	27	43	7	18	28	30	32	27	74	1.26	− 1.9	13	9,218	sw.	42	nw.	17	6	9	16	6.9	0.9	...
Baltimore	123	100	113	30.13	30.27	+ .13	39.5	+ 6.1	71	27	47	10	18	32	27	35	29	70	1.51	− 1.7	14	6,825	sw.	36	n.	14	7	7	17	6.6	1.5	...
Washington	112	62	85	30.13	30.26	+ .13	39.8	+ 6.9	71	31	49	8	9	31	29	35	29	69	1.57	− 1.8	13	5,257	s.	35	nw.	3	7	9	15	6.5	5.7	...
Lynchburg	681	153	188	29.51	30.27	+ .14	43.2	+ 7.4	72	28	53	10	9	34	34	37	32	72	0.99	− 2.7	9	6,087	sw.	34	nw.	3	6	12	13	6.4	1.7	...
Norfolk	91	170	205	30.18	30.29	+ .16	47.0	+ 6.6	72	24	56	17	18	38	32	42	37	75	2.07	− 1.3	10	11,046	sw.	48	sw.	5	8	12	11	5.6	T.	...
Richmond	144	11	52	30.12	30.28	+ .15	44.0	+ 6.0	74	28	54	12	18	34	29	39	34	74	1.51	− 1.5	9	7,169	s.	37	sw.	5	7	10	14	6.2	2.6	...
Wytheville	2,293	49	55	27.82	30.27	+ .13	40.4	+ 7.4	66	12	50	4	18	31	35	36	33	81	3.57	− 0.7	13	5,109	w.	32	sw.	1	8	9	14	6.0	0.3	...
South Atlantic States.							52.8	+ 7.6										81	1.62	− 2.3										5.9		
Asheville	2,255	70	84	27.86	30.28	+ .13	44.8	+ 9.4	67	1	54	6	18	36	34	40	36	76	2.54	− 2.1	12	8,197	se.	33	nw.	17	8	6	17	6.6	T.	...
Charlotte	773	153	161	29.42	30.28	+ .13	47.6	+ 7.2	71	2	56	18	18	40	24	44	40	79	1.66	− 2.6	17	8,272	sw.	37	nw.	17	7	5	19	6.3	...	...
Hatteras	11	12	50	30.27	30.28	+ .14	51.2	+ 5.4	72	27	58	24	18	44	28	48	45	85	1.26	− 3.7	12	11,459	sw.	42	ne.	7	8	14	9	5.6	T.	...
Manteo	12	4	46	...	...	...	49.6	...	75	2	60	15	18	39	...	...	...	...	2.76	− 1.9	6	...	sw.	...	...	...	15	7	9	...	...	...
Raleigh	376	103	110	29.88	30.29	+ .16	47.8	+ 7.4	73	26	57	16	18	38	31	42	37	72	2.69	− 0.9	14	6,363	sw.	28	nw.	3	7	8	16	6.6	...	...
Wilmington	78	81	91	30.21	30.30	+ .16	52.9	+ 7.3	76	2	63	20	18	43	36	47	44	80	1.12	− 2.4	10	5,964	sw.	26	ne.	23	12	11	8	5.0	T.	...
Charleston	48	11	92	30.23	30.28	+ .13	55.9	+ 6.6	77	2	64	28	18	48	31	51	48	84	1.34	− 2.1	9	7,900	ne.	37	ne.	23	10	12	9	5.2	...	...
Columbia, S. C.	351	41	57	29.90	30.30	+ .15	52.9	+ 7.8	77	12	62	22	18	44	34	47	43	77	1.32	− 2.0	11	5,936	ne.	35	sw.	22	7	9	15	6.2	...	...
Augusta	180	89	97	30.08	30.28	+ .12	54.0	+ 8.1	78	12	63	24	18	45	35	49	47	82	0.75	− 3.4	7	5,024	ne.	24	w.	22	10	7	14	5.8	...	...
Savannah	65	150	194	30.20	30.27	+ .12	58.2	+ 8.3	79	11	67	30	18	49	31	53	50	84	1.43	− 1.7	13	9,139	ne.	32	e.	15	9	8	14	5.9	...	...
Jacksonville	43	209	245	30.20	30.25	+ .10	62.4	+ 8.5	79	7	70	30	18	55	30	57	55	88	0.90	− 2.2	9	9,796	ne.	36	sw.	16	10	14	7	5.4	...	...
Florida Peninsula.							70.9	+ 6.4										79	1.03	− 1.7										4.0		
Key West	22	10	64	30.13	30.15	+ .05	73.8	+ 5.0	83	23	78	64	19	69	13	68	65	80	1.37	− 0.6	6	8,620	e.	29	e.	26	19	10	2	3.0	...	...
Miami	25	71	79	30.17	30.20	...	72.0	+ 4.7	81	17	76	55	19	68	18	66	63	76	1.44	− 2.0	7	8,699	e.	30	e.	21	8	19	4	5.0	...	...
Sand Key	23	39	72	30.11	30.14	+ .04	72.6	...	78	23	75	64	19	70	9	69	66	79	1.65	...	13	14,065	e.	42	se.	5	18	11	2	3.6	...	...
Tampa	35	79	96	30.18	30.22	+ .10	67.0	+ 9.6	80	22	76	41	18	58	27	60	58	82	0.29	− 2.5	5	5,578	ne.	25	e.	26	15	10	6	4.3	...	...
East Gulf States.							54.8	+ 7.5										81	3.67	− 1.3										6.5		
Atlanta	1,174	190	216	29.00	30.27	+ .12	48.8	+ 6.6	73	29	57	14	18	41	35	45	42	80	2.53	− 2.8	11	9,742	se.	40	nw.	17	6	7	18	6.7	T.	...
Macon	370	78	87	29.86	30.26	+ .10	54.2	+ 8.6	77	12	64	18	18	45	31	49	46	78	1.74	− 3.4	10	5,115	s.	25	s.	12	9	5	17	6.3	...	...
Thomasville	273	8	57	29.94	30.24	+ .08	60.1	+ 9.1	78	28	70	25	18	50	36	54	50	81	2.03	− 2.1	6	4,157	ne.	20	s.	12	10	11	10	5.5	...	...
Pensacola	56	140	182	30.16	30.22	+ .08	58.2	+ 5.9	79	7	64	27	18	52	26	55	52	84	1.72	− 2.3	9	11,005	se.	38	se.	12	7	10	14	6.5	...	...
Anniston	741	9	57	24.46	30.26	+ .10	50.8	+ 8.6	75	28	60	14	18	41	33	...	...	...	4.11	− 1.2	12	6,112	se.	24	se.	15	6	12	13	6.0	0.3	...
Birmingham	700	11	48	29.47	30.26	+ .10	51.2	+ 6.1	75	12	60	15	18	42	32	46	42	75	5.40	+ 0.1	11	7,186	s.	36	s.	12	6	7	18	7.1	0.6	...
Mobile	57	125	161	30.15	30.21	+ .06	57.2	+ 7.4	77	7	65	25	18	50	31	54	53	88	3.06	− 1.8	10	8,821	se.	45	n.	17	7	17	7	5.7	...	...
Montgomery	223	100	112	30.00	30.25	+ .09	55.4	+ 7.7	77	28	65	21	18	46	30	50	46	75	3.63	− 1.5	9	5,854	e.	27	n.	17	8	13	10	5.8	T.	...
Meridian	375	85	93	29.81	30.22	+ .06	52.9	+ 7.9	79	12	62	20	18	44	41	49	46	82	5.83	+ 0.3	7	4,923	se.	25	se.	21	6	6	19	7.1	T.	...
Vicksburg	247	65	74	29.92	30.21	+ .06	53.2	+ 6.2	79	11	62	22	18	45	43	49	46	80	5.83	+ 0.2	8	6,461	se.	36	nw.	12	5	6	20	7.4	...	...
New Orleans	51	76	84	30.13	30.18	+ .05	61.3	+ 8.3	79	11	69	33	14	53	29	57	56	87	4.46	− 0.2	10	5,881	se.	28	nw.	12	2	14	15	6.9	...	...
West Gulf States.							51.0	+ 4.9										82	4.81	+ 1.8										7.8		
Shreveport	249	77	93	29.89	30.17	...	51.6	+ 5.4	79	11	61	15	13	43	55	47	44	79	6.29	+ 1.9	13	6,789	se.	31	s.	11	6	3	22	7.4	...	...
Bentonville	1,303	11	44	28.70	30.11	− .03	37.0	+ 2.9	69	11	47	− 5	13	27	46	...	...	...	11.18	+ 8.6	14	5,627	s.	32	s.	1	6	2	23	7.7	0.9	...
Fort Smith	457	79	94	29.64	30.14	.00	42.6	+ 4.3	75	11	52	4	13	33	65	38	34	77	7.28	+ 4.8	12	7,997	e.	46	w.	12	6	2	23	7.7	0.1	...
Little Rock	357	139	147	29.80	30.18	+ .03	45.2	+ 4.6	75	11	54	10	13	36	57	42	38	79	8.45	+ 3.7	14	8,021	s.	38	nw.	12	7	4	20	7.3	0.1	...
Brownsville	57	3	40	...	...	...	67.2	...	84	31	77	30	17	58	42	...	...	...	0.19	...	5	...	s.	...	...	...	...	...	...	...	...	...
Corpus Christi	20	69	77	30.07	30.09	− .01	60.4	+ 6.9	77	1	67	26	13	54	37	58	56	88	0.31	− 1.9	11	10,540	se.	50	se.	20	4	11	16	6.8	...	...
Dallas	512	109	117	29.58	30.14	...	46.6	...	79	5	56	9	13	37	56	...	...	...	5.88	...	13	8,290	nw.	41	s.	11	3	6	22	8.2	0.1	...
Fort Worth	670	106	114	29.39	30.12	.00	46.2	+ 1.9	80	5	56	10	13	37	38	42	39	81	4.01	+ 3.1	11	8,771	nw.	44	nw.	12	3	6	22	8.0	0.1	...
Galveston	54	106	114	30.08	30.14	− .04	58.4	+ 5.7	72	7	64	27	13	53	39	56	54	88	0.86	− 2.8	6	10,114	se.	41	nw.	12	8	6	17	6.8	...	...
Houston	138	111	121	29.97	30.12	...	59.2	+ 6.3	78	11	68	21	13	51	45	...	...	...	2.81	...	11	7,980	se.	38	s.	11	5	7	19	7.4	...	...
Palestine	510	64	72	29.59	30.13	+ .01	52.4	+ 6.9	78	11	62	13	13	43	56	48	45	84	4.20	+ 0.3	13	6,609	s.	32	s.	11	4	5	22	7.5	T.	...
San Antonio	701	109	132	29.34	30.08	− .02	56.2	+ 5.1	82	11	66	22	13	47	40	52	48	78	2.25	+ 0.6	15	7,026	ne.	39	n.	12	5	7	19	7.2	...	...
Taylor	582	55	63	29.51	30.13	+ .02	51.6	+ 4.1	78	1	60	15	13	43	51	...	...	...	3.29	+ 0.5	13	8,498	n.	44	s.	11	5	2	24	7.8	...	...

TABLE I.—*Climatological data for United States Weather Bureau stations, January, 1916*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.		%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee.							39.9	+6.7										78	6.11	+2.3										7.1		
Chattanooga	762	189	213	29.45	30.28	+0.12	47.2	+6.6	72	11	55	12	17	39	31	43	38	73	4.75	-0.8	17	7,006	s.	49	sw.	12	6	5	20	7.1	0.9	....
Knoxville	996	93	100	29.18	30.26	+.11	45.0	+7.5	72	26	54	10	17	36	36	41	37	76	5.23	+0.3	13	4,103	sw.	32	sw.	31	6	7	18	7.0	1.0	....
Memphis	399	76	97	29.79	30.23	+.07	46.2	+5.9	75	11	54	13	13	38	52	43	40	77	7.16	+2.0	14	7,730	s.	38	n.	12	9	1	21	7.3	T.	....
Nashville	546	168	191	29.65	30.25	+.09	44.6	+6.6	74	12	54	5	17	36	46	41	38	78	7.62	+2.8	14	9,149	se.	57	se.	12	7	4	20	6.8	0.5	....
Lexington	989	193	230	29.14	30.24	+.11	39.7	+6.7	69	30	49	-4	17	31	34	....	....	....	5.65	+1.8	18	12,760	s.	52	sw.	5	7	7	17	6.9	8.7	....
Louisville	525	219	255	29.64	30.24	+.10	40.0	+5.7	72	12	49	0	17	31	52	36	32	76	8.16	+4.3	17	11,355	s.	52	s.	12	6	10	15	6.9	4.7	....
Evansville	431	72	82	29.73	30.21	+.07	38.6	+6.3	69	12	48	3	17	30	57	36	33	81	8.73	+5.0	15	10,943	s.	50	s.	12	7	8	16	7.0	3.8	....
Indianapolis	822	194	230	29.28	30.20	+.08	33.8	+5.6	68	12	44	-3	17	24	58	31	28	81	6.55	+3.7	15	10,773	s.	44	w.	13	9	5	17	6.8	0.6	....
Terre Haute	575	96	129	29.55	30.19	......	33.8	......	65	12	44	-3	14	24	61	31	28	81	7.58	......	16	9,410	s.	45	s.	12	5	8	18	7.1	1.4	....
Cincinnati	628	11	51	29.52	30.22	+.10	37.6	+5.3	70	12	48	-4	17	28	41	34	31	80	5.84	+2.5	19	7,404	s.	34	s.	12	6	8	17	7.0	5.3	....
Columbus	824	173	222	29.31	30.21	+.10	36.0	+7.4	68	27	45	-4	17	27	33	33	30	82	5.02	+2.1	16	9,985	s.	46	w.	13	6	9	16	6.7	1.8	....
Dayton	899	181	216	29.20	30.18	......	36.4	+7.5	67	12	46	-3	17	27	35	33	30	83	5.67	+2.7	16	10,207	sw.	49	s.	12	6	9	16	6.7	0.4	....
Pittsburgh	842	353	410	29.28	30.21	+.10	37.5	+6.8	69	27	46	-3	17	28	38	34	29	73	3.51	+0.6	15	9,898	sw.	52	w.	13	6	2	23	7.9	1.3	....
Elkins	1,940	41	50	28.13	30.27	+.15	37.8	+8.8	72	12	50	-5	8	26	44	33	29	79	6.31	+3.0	16	3,462	w.	28	w.	13	4	8	19	7.6	8.3	....
Parkersburg	638	77	84	29.57	30.25	+.13	38.8	+7.5	74	27	49	-1	17	28	42	35	32	79	5.34	+2.2	17	4,902	se.	32	w.	13	8	5	18	7.2	3.2	....
Lower Lake Region.							31.4	+7.1										78	2.96	+0.3										7.6		
Buffalo	767	247	280	29.27	30.13	+.06	32.0	+7.3	66	27	40	2	17	24	30	29	25	78	2.96	-0.3	20	18,890	sw.	76	w.	13	3	9	19	7.8	10.9	....
Canton	448	10	61	29.62	30.12	......	25.0	+8.7	58	28	36	-8	14	14	44	....	....	....	2.52	-0.6	19	11,367	sw.	46	sw.	13	5	6	20	7.4	8.2	T.
Oswego	335	76	91	29.75	30.14	+.07	30.0	+6.1	61	27	38	1	8	22	36	28	25	81	2.95	-0.2	18	11,727	s.	39	nw.	22	1	5	25	8.8	15.7	....
Rochester	523	97	113	29.56	30.15	+.08	32.4	+8.4	63	27	41	2	17	24	32	29	24	72	2.13	-1.0	14	8,718	sw.	39	sw.	13	1	7	23	8.4	8.5	....
Syracuse	597	97	113	29.49	30.16	+.09	31.1	+8.1	64	27	40	1	14	22	44	28	23	73	2.00	-0.1	17	12,500	s.	48	nw.	3	2	7	22	8.1	3.6	....
Erie	714	130	166	29.35	30.14	+.06	34.4	+7.9	67	27	43	4	17	26	30	31	26	73	2.23	-0.8	18	15,184	sw.	54	se.	12	2	9	20	7.7	3.9	....
Cleveland	762	190	201	29.32	30.17	+.08	34.8	+8.6	69	27	44	-10	17	26	37	31	27	77	2.40	0.0	17	12,735	s.	53	s.	10	5	5	21	7.6	3.1	....
Sandusky	629	62	103	29.46	30.16	+.07	33.6	+7.3	69	27	42	-4	17	25	37	30	26	77	3.62	+1.5	16	11,945	w.	46	w.	13	3	12	16	7.3	3.9	....
Toledo	628	208	243	29.46	30.16	+.07	32.0	+6.4	66	27	40	-3	17	24	37	30	26	81	4.53	+2.6	16	14,309	sw.	54	sw.	13	8	7	16	6.4	4.6	....
Fort Wayne	856	113	124	29.22	30.18	......	30.4	+3.5	65	27	39	-8	17	22	46	28	24	80	6.48	......	14	9,373	sw.	38	s.	27	7	8	16	6.6	9.8	....
Detroit	730	218	245	29.32	30.14	+.06	30.0	+5.7	61	27	38	-2	17	22	35	28	25	84	4.31	+2.3	13	10,872	sw.	50	w.	13	6	8	17	7.0	1.1	....
Upper Lake Region.							21.6	+3.3										82	3.27	+1.2										7.7		
Alpena	609	13	92	29.37	30.06	+.02	24.0	+5.3	50	27	31	-2	16	17	30	22	20	85	2.00	-0.2	19	10,852	w.	52	w.	22	1	11	19	8.0	7.2	1.0
Escanaba	612	54	60	29.36	30.06	+.01	17.0	+2.5	41	21	25	-15	6	9	43	16	12	79	2.12	+0.6	13	8,459	nw.	40	nw.	22	10	8	13	5.7	8.9	3.5
Grand Haven	632	54	92	29.39	30.10	+.03	28.2	+3.7	61	27	35	1	14	21	35	27	23	81	3.78	+1.0	21	12,686	w.	52	w.	5	4	1	26	8.3	11.6	....
Grand Rapids	707	70	87	29.32	30.11	+.05	28.7	+4.9	62	27	36	0	17	22	41	27	24	81	3.90	+1.1	22	6,820	w.	32	nw.	5	1	2	28	9.1	10.4	....
Houghton	684	62	72	29.28	30.04	-.01	15.6	+1.1	43	24	23	-10	7	8	28	....	....	....	5.14	+3.1	26	8,301	w.	44	w.	22	0	4	27	9.3	49.9	42.7
Lansing	878	11	62	29.14	30.11	......	27.6	+5.6	61	27	35	-2	17	20	41	26	23	83	3.11	+1.0	20	7,055	s.	31	w.	5	4	5	22	8.1	3.6	....
Ludington	637	60	66	29.35	30.07	......	26.6	......	58	27	33	0	16	20	34	25	23	85	3.33	......	21	11,766	w.	40	w.	2	2	3	26	8.8	11.0	1.1
Marquette	734	77	111	29.23	30.07	+.03	17.4	+1.5	46	24	25	-13	6	10	36	16	12	78	3.05	+1.0	14	9,974	sw.	55	w.	22	3	6	22	8.2	25.0	17.6
Port Huron	638	70	120	29.40	30.12	+.06	28.6	+6.8	59	27	36	-2	17	21	37	27	24	84	3.18	+1.3	14	10,759	sw.	38	sw.	13	2	12	17	7.5	1.7	....
Saginaw	641	48	82	29.39	30.10	......	27.6	......	62	27	35	-2	17	20	40	26	24	88	2.51	+0.2	15	9,809	s.	40	w.	5	1	8	22	8.6	1.8	....
Sault Ste. Marie	614	11	61	29.32	30.05	+.02	17.0	+3.7	44	24	25	-17	17	9	32	16	12	81	3.18	+1.0	24	8,280	e.	55	w.	22	2	6	23	8.4	23.4	18.8
Chicago	823	140	310	29.22	30.14	+.04	28.8	+5.1	62	27	37	-6	13	21	45	27	23	75	4.84	+2.8	15	11,551	w.	42	s.	21	10	4	17	6.4	2.7	....
Green Bay	617	109	144	29.38	30.08	+.02	18.6	+4.0	47	24	27	-15	14	10	41	17	13	77	2.39	+0.7	10	10,458	s.	42	nw.	5	7	9	15	6.6	8.8	3.2
Milwaukee	681	119	133	29.33	30.10	+.02	24.0	+4.2	56	27	33	-15	13	15	49	23	20	82	3.08	+1.1	14	9,316	w.	44	e.	11	8	8	15	6.3	8.9	1.7
Duluth	1,133	11	47	28.80	30.10	+1.0	5.1	-5.3	38	24	16	-33	13	-5	39	5	3	92	3.48	+2.5	12	12,008	sw.	62	nw.	12	10	9	12	5.6	36.6	20.8
North Dakota.							-5.9	-10.0										87	1.04	+0.4										5.7		
Moorehead	940	8	57	29.11	30.21	+.07	-2.2	-4.9	31	9	9	-37	13	-13	39	-4	-7	83	1.49	+0.8	10	7,177	nw.	36	nw.	10	13	5	13	5.0	14.9	19.0
Bismarck	1,674	8	57	28.32	30.26	+.13	-5.0	-11.7	36	21	6	-45	13	-16	40	-7	-10	82	0.81	+0.3	8	7,727	nw.	44	nw.	10	9	13	9	5.1	12.1	12.8
Devils Lake	1,482	11	44	28.47	30.18	+.06	-8.2	-8.5	27	21	1.7	-44	12	-18	39	-10	-12	89	0.71	+0.1	10	9,757	w.	38	w.	5	7	11	13	5.9	9.5	10.1
Williston	1,872	40	47	28.08	30.23	+.12	-8.2	-14.7	30	23	1.0	-42	12	-18	35	-9	-11	93	1.17	+0.6	10	6,058	nw.	32	w.	15	5	10	16	6.7	11.2	14.1
Upper Mississippi Valley.							24.4	+2.8										81	4.45	+2.8										6.6		
Minneapolis	918	10	208	29.10	30.11	......	10.0	......	44	24	21	-30	13	0	42	....	....	....	2.88	+2.2	11	9,708	nw.	48	nw.	12	7	9	15	6.5	23.9	14.7
St. Paul	837	201	236	29.16	30.12	+.01	10.4	-1.2	45	24	21	-31	13	0	42	....	....	....	2.60	+1.7	13	10,087	nw.	46	nw.	12	8	11	12	6.1	20.5	14.8
La Crosse	714	11	48	29.31	30.12	+.01	17.0	+1.8	50	23	26	-25	13	8	37	....	....	....	2.48	+1.4	11	5,176	s.	23	w.	5	10	4	17	6.3	7.8	....
Madison	974	70	78	29.02	30.13	+.03	20.2	+3.7	48	27	29	-22	13	11	48	18	14	79	3.07	+1.5	13	8,179	w.	34	nw.	5	8	7	16	6.7	6.8	1.5
Charles City	1,015	10	49	29.00	30.14	.00	15.0	+3.6	46	24	25	-26	13	5	37	14	12	88	2.63	+1.7	12	6,523	nw.	30	nw.	5	7	10	14	6.2	8.9	2.0
Davenport	606	71	79	29.46	30.15	+.03	24.2	+3.4	55	5	34	-22	13	14	54	22	19	82	4.63	+3.1	12	6,949	nw.	38	e.	29	9	6	16	6.5	6.2	2.3
Des Moines	861	84	97	29.20	30.15	+.01	20.8	+0.4	54	4	31	-20	13	11	34	18	15	82	2.66	+1.4	13	6,428	nw.	26	nw.	12	6	5	20	7.4	5.8	1.5
Dubuque	698	81	96	29.38	30.17	+.05	21.6	+3.3	51	4	31	-22	13	12	53	19	16	80	2.46	+1.0	12	5,779	nw.	31	nw.	5	8	7	16	6.4	7.4	1.1
Keokuk	614	64	78	29.46	30.17	+.03	27.0	+3.3	59	5	37	-17	13	17	54	24	21	81	5.18	+3.5	12	6,634	nw.	30	w.	1	12	4	15	5.8	3.0	T.
Cairo	356	87	93	29.80	30.20	+.04	40.0	+5.2	67	12	48	6	17	31	53	37	34	80	8.11	+4.3	16	8,954	s.	44	sw.	1	7	6	18	7.1	0.2	....
Peoria	609	11	45	29.48	30.17	+.05	27.2	+4.1	60	27	36	-17	13	18	49	26	23	87	5.95	+3.8	14	6,901	s.	30	w.	12	9	4	18	6.4	3.9	T.
Springfield, Ill	644	10	91	29.46	30.17	+.04	29.6	+3.3	62	27	38	-9	13	21	47	27	24	78	4.77	+2.5	13	8,250	s.	32	w.	12	10	1	20	6.8	1.5	....
Hannibal	534	74	109	29.56	30.16	+.03	28.8	+2.1	61	1	39	-13	13	18	50	....	....	....	6.40	+4.2	14	7,790	nw.	36	sw.	1	10	3	18	6.5	4.8	0.9
St. Louis	567	265	303	29.55	30.17	+.03	34.1	+3.1	65	1	43	-4	13	25	48	31	26	71	8.53	+6.3	16	12,248	s.	49	s.	4	8	3	20	7.1	2.7	....
Missouri Valley.							18.0	-3.1										82	3.34	+2.4										5.9		
Columbia, Mo	781	11	84	29.28	30.15	+.02	30.6	+3.4	63	5	41	-11	13	20	47	....	....	....	6.80	+4.6	15	7,316	se.	32	nw.	5	7	4	20	7.1	3.0	0.8
Kansas City	963	161	181	29.09	30.17	+.02	27.4	+1.2	62	5	37	-14	13	18	48	24	20	77	5.52	+4.4	16	10,185	s.	46	n.	5	7	10	14	6.4	9.8	1.5
St. Joseph	967	11	49	29.09	30.17	......	24.2	......	61	4	34	-19	13	15	49	21	18	84	2.56	......	13	7,746	nw.	39	nw.	1	9	7	15	6.4	5.6	1.5
Springfield, Mo	1,324	98	104	28.70	30.16	+.02	33.8	+2.5	64	5	43	-8	13	24	50	31	29	85	9.31	+6.6	13	9,920	se.	34	nw.	12	10	3	18	6.4	0.8	1.0
Iola	984	11	50	29.05	30.15	-.01	28.5	+0.9	64	5	38	-12	13	19	46	....	....	....	5.13	+4.2	11	7,243	n.	27	n.	5	7	7	17	6.6	2.5	1.6
Topeka	983	85	101	......	......	......	24.8	-0.8	63	4	34	-15	13	15	49	....	....	....	2.69	+1.8	13	8,487	s.	37	sw	1	7	10	14	6.6	7.1	1.8
Drexel	1,299	10	53	28.72	30.18	......	15.2	......	53	4	24	-24	13	6	30	13	12	90	1.46	......	9	9,697	nw.	40	nw.	1	7	10	14	6.3	8.6	4.9
Lincoln	1,189	11	84	28.85	30.19	+.04	18.3	-2.9	59	4	27	-21	13	10	31	16	13	83	1.44	+0.8	12	9,271	n.	41	nw.	1	9	11	11	5.6	6.2	5.8
Omaha	1,105	115	121	28.94	30.19	+.04	17.2	-3.3	59	4	26	-22	13	9	33	15	11	79	2.20	+1.6	9	8,187	nw.	38	nw.	5	10	9	12	5.8	10.2	4.0
Valentine	2,598	47	54	27.30	30.20	+.08	7.8	-10.4	50	9	18	-30	13	-3	48	6	1	76	0.74	+0.2	5	7,168	nw.	39	w.	20	13	10	8	4.7	10.2	4.8
Sioux City	1,135	94	164	28.90	30.18	+.03	12.0	-3.6	44	4	20	-28	13	3	33	10	7	82	1.73	+1.2	11	11,343	nw.	50	nw.	27	14	7	10	5.1	16.8	8.4
Huron	1,306	59	74	28.72	30.22	+.06	2.4	-7.1	38	9	14	-40	13	-9	46	2	0	88	2.00	+1.5	10	8,891	nw.	37	nw.	9	10	13	8	5.1	23.2	13.4
Pierre	1,572	70	75	28.46	30.26	+.13	2.4	-11.5	44	9	13	-35	13	-8	42	2	-3	76	1.06	+0.6	6	6,977	nw.	45	nw.	9	12	12	7	4.4	14.2	8.5
Yankton	1,233	49	57	28.78	30.18	+.02	10.2	-5.3	46	9	20	-29	13	1	43	....	....	....	1.48	+0.9	9	7,462	nw.	30	nw.	12	7	15	9	6.2	12.2	6.0

TABLE I.—*Climatological data for United States Weather Bureau stations, January, 1916*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation: Total.	Departure from normal.	Days with 0.01 or more.	Wind: Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0–10	In.	In.
Northern Slope.							5.7	−13.3										76	1.34	+ 0.5										5.6		
Havre	2,505	11	44	27.42	30.30	+0.20	−13.3	−26.8	30	21	−4	−57	27	−23	43	−13	−15	87	1.75	+ 1.1	10	5,621	w.	36	sw.	21	12	4	15	6.1	17.5	22.5
Helena	4,110	87	114	25.70	30.18	+ .03	−1.2	−21.2	53	23	8	−32	29	−10	60	− 3	− 8	74	1.26	+ 0.3	14	4,562	sw.	39	sw.	22	4	16	11	6.5	17.2	6.1
Kalispell	2,962	11	34	26.84	30.10	− .02	4.4	−15.2	48	23	13	−22	31	−4	38	3	1	84	1.95	+ 0.4	17	3,989	nw.	30	sw.	24	8	7	16	6.5	19.2	8.2
Miles City	2,371	26	48	27.55	30.31	+ .19	−6.3	−20.8	43	23	4	−46	12	−17	46	− 8	−12	77	1.38	+ 0.8	9	3,874	nw.	27	nw.	9	17	7	7	4.1	15.3	13.1
Rapid City	3,259	50	58	26.56	30.20	+ .10	9.6	−11.9	59	3	22	−33	12	−3	58	6	− 2	62	0.57	+ 0.1	7	6,468	w.	48	sw.	9	14	12	5	4.5	6.2	1.0
Cheyenne	6,088	84	101	23.82	30.03	− .02	17.6	− 8.0	53	23	28	−19	16	7	37	15	9	67	0.63	+ 0.2	9	9,793	w.	70	w.	21	7	10	14	6.3	6.4	2.0
Lander	5,372	60	68	24.47	30.11	− .01	8.6	− 8.8	56	23	22	−34	29	−5	46	5	− 1	68	1.03	+ 0.6	6	3,780	e.	48	w.	19	8	15	8	5.1	11.4	9.0
Sheridan	3,790	10	47	26.03	30.20	......	1.8	......	56	3	14	−29	12	−10	67	− 1	− 5	82	0.92	......	11	3,607	n.	34	sw.	9	10	12	9	5.2	10.0	6.4
Yellowstone Park	6,200	11	48	23.64	30.05	− .09	6.7	−10.9	36	23	15	−31	27	−2	48	6	2	78	2.60	+ 0.4	17	7,130	s.	37	s.	21	4	7	20	7.2	31.2	20.6
North Platte	2,821	11	51	27.11	30.20	+ .08	15.0	− 6.4	56	23	26	−22	13	4	39	11	8	79	0.85	+ 0.4	12	5,351	w.	27	nw.	1	13	7	11	4.9	7.9	4.2
Middle Slope.							26.0	− 3.1										76	1.48	+ 0.8										6.0		
Denver	5,291	129	172	24.58	30.03	− .02	22.8	− 6.3	65	4	35	−12	12	11	42	18	10	65	0.53	+ 0.1	8	5,403	sw.	42	sw.	9	8	16	7	5.4	9.0	3.0
Pueblo	4,685	80	86	25.18	30.00	− .05	27.1	− 2.0	68	8	40	− 8	29	14	54	22	14	64	0.22	− 0.1	8	5,497	nw.	56	w.	9	15	9	7	4.3	5.8	1.8
Concordia	1,392	50	58	28.64	30.19	+ .05	21.5	− 2.9	68	4	30	−16	13	13	32	19	17	87	1.34	+ 0.6	14	7,010	nw.	32	nw.	12	5	11	15	7.0	9.7	4.2
Dodge	2,509	11	51	27.44	30.16	+ .05	23.8	− 3.5	73	4	35	−16	13	13	35	20	16	76	0.59	+ 0.1	12	7,510	n.	35	nw.	1	8	12	11	6.0	5.5	3.2
Wichita	1,358	139	158	28.64	30.14	+ .01	27.1	− 2.6	68	4	36	−11	13	18	43	24	21	83	1.90	+ 1.1	13	10,939	s.	48	sw.	4	9	7	15	6.3	2.1	0.8
Oklahoma	1,214	10	47	28.82	30.15	+ .04	33.4	− 1.3	68	4	43	− 4	13	24	40	30	28	84	4.28	+ 2.9	12	12,549	n.	44	n.	5	5	10	16	7.2	2.7	2.0
Southern Slope.							44.5	+ 3.0										64	0.45	− 0.2										6.0		
Abilene	1,738	10	52	28.25	30.09	.00	45.2	+ 2.6	81	11	56	9	13	34	47	38	32	69	0.40	− 0.5	9	8,477	n.	41	s.	20	5	4	22	7.7	0.1	....
Amarillo	3,676	10	49	26.23	30.05	− .01	35.2	+ 1.3	74	9	49	1	13	21	55	29	23	70	0.36	− 0.2	5	8,740	sw.	36	sw.	4	14	9	8	4.7	2.5	....
Del Rio	944	64	71	29.04	30.04	− .02	55.4	+ 5.2	80	30	64	24	17	47	33	......	......	......	0.60	− 0.2	10	6,976	se.	38	nw.	12	8	7	16	6.6	......	....
Roswell	3,566	75	85	26.34	30.00	− .04	42.1	+ 2.9	77	9	55	13	17	30	44	34	25	54	0.44	− 0.1	5	5,973	s.	44	sw.	11	12	9	10	5.2	0.4	....
Southern Plateau.							39.4	− 1.3										62	3.05	+ 2.3										4.8		
El Paso	3,762	110	133	26.17	29.96	− .05	50.4	+ 6.3	74	6	62	23	13	39	39	40	28	45	0.66	+ 0.2	4	8,704	w	58	sw.	11	9	15	7	5.0	......	......
Santa Fe	7,013	57	66	23.15	30.01	− .03	30.6	+ 2.1	52	3	39	2	31	22	32	26	22	75	3.02	+ 2.4	17	4,998	sw.	30	se.	28	9	8	14	5.7	27.3	2.5
Flagstaff	6,908	8	57	23.22	29.94	− .11	24.6	− 2.1	48	23	36	−25	31	13	45	......	......	......	8.16	......	17	......	w.	54	sw.	28	10	13	8	....	54.4	3.4
Phoenix	1,108	76	81	28.83	30.01	− .02	50.8	+ 0.8	69	3	60	31	12	42	31	45	39	69	2.34	+ 1.2	11	3,826	e.	26	s.	28	10	11	10	5.3	......	......
Yuma	141	9	54	29.86	30.01	− .04	53.4	− 1.3	72	5	64	28	12	43	34	32	46	38	0.52	+ 0.1	7	4,502	ne.	39	s.	27	20	5	6	3.2	......	......
Independence	3,910	11	42	25.88	29.96	− .11	26.7	−13.8	52	27	37	− 2	21	16	..	......	......	......	8.69	+ 7.8	12	3,942	n.	48	se.	27	5	12	14	....	75.7	18.5
Middle Plateau.							24.2	− 4.2										80	2.93	+ 1.9										7.0		
Reno	4,532	74	81	25.27	29.93	− .20	22.8	− 9.7	48	22	33	−17	21	13	43	21	18	79	6.76	+ 4.8	17	4,217	w.	39	w.	8	7	8	16	6.8	65.7	16.1
Tonopah	6,090	12	20	23.87	29.97	......	23.6	......	39	3	29	4	12	18	19	22	20	85	2.02	+ 1.3	13	8,609	se.	43	se.	3	10	4	17	6.2	16.1	3.4
Winnemucca	4,344	18	56	25.43	29.92	− .24	22.1	− 6.7	51	3	33	−15	21	11	45	21	18	81	2.21	+ 1.2	15	6,294	sw.	42	sw.	28	5	9	17	7.1	20.8	5.6
Modena	5,479	10	43	24.46	29.93	− .17	24.4	− 3.1	44	3	34	−17	12	15	39	23	20	80	3.47	+ 2.7	13	8,319	sw.	74	s.	27	7	7	17	6.3	21.1	3.5
Salt Lake City	4,360	147	189	25.47	29.92	− .23	29.4	+ 0.6	52	8	37	9	12	22	22	26	21	71	1.96	+ 0.6	15	6,356	nw.	48	s.	8	3	8	20	7.9	19.8	9.6
Grand Junction	4,602	82	96	25.30	29.98	− .08	22.5	− 2.2	50	28	32	− 7	31	13	34	21	18	85	1.18	+ 0.7	16	3,842	nw.	51	sw.	28	4	8	19	7.5	15.2	2.8
Northern Plateau.							19.9	− 8.9										78	1.92	+ 0.3										7.7		
Baker	3,471	48	53	26.26	29.96	− .20	16.2	− 7.7	46	23	25	−11	16	8	28	16	12	80	0.85	− 0.5	14	4,772	se.	24	se.	20	6	6	19	6.9	10.4	3.0
Boise	2,739	78	86	27.04	29.96	− .20	27.4	− 1.9	51	3	34	4	20	21	32	25	20	72	1.93	0.0	20	5,277	se.	32	se.	2	1	3	27	9.0	13.6	3.4
Lewiston	757	40	48	29.16	30.00	− .16	17.8	−16.7	57	23	26	−13	17	10	34	......	......	......	1.65	+ 0.1	13	2,383	e.	28	s.	21	4	7	20	7.1	21.8	4.2
Pocatello	4,477	46	54	25.31	29.96	− .24	23.0	− 2.1	44	3	30	− 8	17	16	28	21	17	79	2.44	+ 1.8	15	7,559	se.	37	sw.	9	1	11	19	7.9	23.1	7.0
Spokane	1,929	101	110	27.85	29.98	− .14	16.6	−10.1	49	23	23	−11	31	10	27	16	11	76	1.88	− 0.4	20	5,326	ne.	36	sw.	20	3	9	19	7.5	18.1	3.5
Walla Walla	991	57	65	28.86	29.98	− .17	18.6	−14.6	59	23	25	− 7	16	12	37	17	14	85	2.79	+ 0.8	18	3,543	s.	28	s.	22	4	7	20	7.8	30.9	11.4
North Pacific Coast Region.							31.9	− 7.5										79	5.74	− 1.0										7.7		
North Head	211	11	56	29.58	29.81	− .24	34.0	− 7.8	48	22	38	22	29	30	16	33	31	87	6.60	− 0.1	21	13,595	e.	94	s.	22	5	4	22	7.7	20.1	2.5
Port Crescent	259	8	53	29.57	29.86	− .13	28.2	− 7.8	55	22	34	10	11	22	24	......	......	......	5.83	+ 0.3	20	7,483	se.	42	ne.	14	4	2	25	8.1	43.9	18.0
Seattle	125	215	250	29.75	29.89	− .16	31.0	− 8.3	51	22	36	14	11	26	24	29	24	74	4.32	− 0.2	16	8,160	se.	41	s.	7	5	6	20	7.5	23.3	6.8
Tacoma	213	113	120	29.63	29.86	− .18	31.2	− 6.9	52	22	36	12	11	27	22	29	23	70	4.03	− 1.8	14	6,791	ne.	40	ne.	17	5	5	21	7.5	19.1	6.0
Tatoosh Island	109	7	57	29.69	29.79	− .19	33.8	− 7.4	47	22	37	23	11	31	13	32	29	83	7.55	− 4.6	19	22,091	e.	75	ne.	15	8	8	15	6.3	22.5	3.8
Portland, Oreg.	153	68	106	29.72	29.88	− .20	29.6	− 9.5	54	22	34	13	12	25	17	28	23	74	5.69	− 0.8	22	6,530	e.	34	e.	17	1	3	27	9.0	32.9	7.9
Roseburg	510	9	57	29.31	29.87	− .23	35.8	− 5.0	55	23	41	21	28	31	18	34	32	86	6.15	+ 0.4	26	1,989	s.	17	se.	23	0	15	16	7.5	20.8	2.0
Middle Pacific Coast Region.							43.2	− 4.1										86	10.92	+ 6.2										7.8		
Eureka	62	73	89	29.84	29.91	− .19	43.0	− 3.9	56	23	48	32	30	38	16	41	39	86	13.02	+ 5.4	28	6,467	se.	43	nw.	27	2	5	24	8.0	1.4	....
Mount Tamalpais	2,375	11	18	27.43	29.94	− .17	36.6	− 9.3	42	2	40	27	29	33	14	36	35	94	12.61	+ 6.7	28	14,748	se.	63	sw.	2	3	4	24	8.3	12.7	3.0
Point Reyes Light	490	7	18	29.38	29.90	......	45.2	− 4.2	54	4	49	35	10	41	15	......	......	......	9.51	......	28	17,351	s.	104	nw.	27	3	11	17	7.1	T.	....
Red Bluff	332	50	56	29.57	29.93	− .19	41.0	− 4.4	53	25	45	29	28	37	19	39	36	84	7.25	+ 3.3	22	5,496	se.	26	s.	8	5	6	20	7.7	11.0	....
Sacramento	69	106	117	29.90	29.97	− .15	43.6	− 2.0	57	2	49	31	1	38	23	41	38	83	9.35	+ 5.7	20	7,746	se.	50	se.	2	2	11	18	7.2	3.5	....
San Francisco	155	209	213	29.79	29.96	− .15	47.0	− 2.5	58	2	52	37	27	42	18	44	41	81	14.59	+10.3	26	6,346	se.	48	sw.	2	4	2	25	8.2	T.	....
San Jose	141	12	110	29.85	30.00	......	46.2	− 2.1	60	23	52	29	31	40	22	......	......	......	8.71	+ 5.8	20	6,474	se.	46	se.	3	2	2	27	8.4	T.	....
South Atlantic Coast Region.							49.0	− 1.8										82	11.06	+ 8.3										6.8		
Fresno	327	89	98	29.65	30.02	− .08	45.6	+ 0.2	66	17	53	28	31	38	23	42	39	78	5.17	+ 3.6	19	4,887	e.	52	sw.	27	4	10	17	7.3	0.7	....
Los Angeles	338	159	191	29.66	30.03	− .05	50.8	− 2.3	64	7	57	38	31	45	23	48	45	83	13.30	+10.5	19	5,821	ne.	34	sw.	27	8	3	20	6.8	......	....
San Diego	87	62	70	29.95	30.05	− .02	52.5	− 1.5	65	23	58	36	12	47	22	49	46	82	7.56	+ 5.6	14	6,399	s.	54	s.	27	10	5	16	6.2	......	....
San Luis Obispo	201	32	40	29.82	30.05	− .04	47.3	− 3.7	62	4	54	29	12	40	25	45	43	85	18.21	+13.5	20	3,257	nw.	25	w.	27	9	2	20	7.1	T.	....
West Indies.																																
San Juan	82	8	54	29.99	30.08	......	74.8	......	83	17	79	66	28	71	14	......	......	......	3.79	− 0.8	22	16,438	ne.	48	ne.	10	2	19	10	6.2	......	....
Panama.																																
Balboa Heights	118	7	97	29.75	29.87	......	80.3	......	90	5	88	68	28	72	22	73	72	87	1.41	+ 0.4	11	5,488	n.	25	n.	9	5	21	5	5.8	......	....
Colon	25	5	71	29.85	29.88	......	81.0	......	86	9	85	74	29	77	11	76	75	86	2.33	− 1.6	11	11,323	ne.	33	n.	23	20	6	5	3.8	......	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during January, 1916, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	20			0.16														0.16			
Albany, N. Y	2			0.67														*			
Alpena, Mich	1–2			0.51														*			
Amarillo, Tex	16–17			0.17														*			
Anniston, Ala	31–Feb.2	3:13 p. m.	D. N. a. m.	3.09	4:43 p. m.	5:07 p. m.	0.12	0.18	0.29	0.46	0.52	0.60									
Asheville, N. C	22			0.59														.46			
Atlanta, Ga	31			0.84														.30			
Atlantic City, N. J	2			0.37														.19			
Augusta, Ga	13			0.31														.24			
Baker, Oreg	14			0.20														*			
Baltimore, Md	22			0.19														.14			
Bentonville, Ark	20–21	7:42 p. m.	7:30 a. m.	1.98	12:22 a. m.	1:03 a. m.	.20	.15	.37	.44	.48	.56	0.62	0.69	0.76	0.81					
Binghamton, N. Y	12–13			0.28														.13			
Birmingham, Ala	21–22	8:35 p. m.	7:21 a. m.	2.54	12:46 a. m.	1:45 a. m.	.59	.12	.25	.34	.48	.54	.61	.70	.88	.99	1.08	1.21			
Bismarck, N. Dak	28–29			0.31														*			
Block Island, R. I	10			0.74														.21			
Boise, Idaho	25			0.35														*			
Boston, Mass	2			0.50														.11			
Buffalo, N. Y	1			0.63														*			
Burlington, Vt	2			0.43														*			
Cairo, Ill	30–31	7:05 p. m.	3:45 a. m.	2.54	7:57 p. m.	8:47 p. m.	.17	.10	.21	.32	.38	.42	.50	.58	.71	.75	.81				
Canton, N. Y	13			0.58														*			
Charles City, Iowa	26–27			0.93														*			
Charleston, S. C	16			0.28														.20			
Charlotte, N. C	6			0.26														.14			
Chattanooga, Tenn	21–22			1.83														.54			
Cheyenne, Wyo	23			0.18														*			
Chicago, Ill	19–21			2.01														*			
Cincinnati, Ohio	12	3:15 p. m.	8:00 p. m.	0.91	3:44 p. m.	4:05 p. m.	.08	.21	.27	.33	.41	.45									
Cleveland, Ohio	5			0.30														.18			
Columbia, Mo	26–27			1.88														*			
Columbia, S. C	13			0.33														.18			
Columbus, Ohio	9–12			2.00														.36			
Concord, N. H	2			0.47														*			
Concordia, Kans	25–26			0.35														*			
Corpus Christi, Tex	19			0.08														.03			
Davenport, Iowa	19–21			1.29														*			
Dayton, Ohio	11–12			1.68														*			
Del Rio, Tex	20			0.44														.40			
Denver, Colo	17			0.23														*			
Des Moines, Iowa	1			0.61														.27			
Detroit, Mich	29–31			1.35														*			
Devils Lake, N. Dak	28–29			0.22														*			
Dodge City, Kans	31			0.10														*			
Dubuque, Iowa	26–27			0.89														*			
Duluth, Minn	25–27			1.41														*			
Durango, Colo	27–28			2.56														*			
Eastport, Me	2–3			0.66														*			
Elkins, W. Va	10–11			1.64														.29			
El Paso, Tex	19–20			0.61														.19			
Erie, Pa	1–2			0.42														*			
Escanaba, Mich	12–13			0.59														*			
Eureka, Cal	22–23			2.28														.31			
Evansville, Ind	28–29			3.46														.61			
Flagstaff, Ariz	25–28			3.92														*			
Fort Smith, Ark	26–27	12:16 p. m.	D. N. a. m.	2.68	9:18 p. m.	9:42 p. m.	1.56	.10	.21	.30	.55	.62									
Fort Wayne, Ind	29–31			1.97														*			
Fort Worth, Tex	19–21			1.19														.51			
Fresno, Cal	5			0.35														.28			
Galveston, Tex	2			0.51														.45			
Grand Haven, Mich	19–21			1.02														*			
Grand Junction, Colo	28			0.15														.11			
Grand Rapids, Mich	20–22			1.07														.27			
Green Bay, Wis	26–27			0.73														*			
Hannibal, Mo	11–12			1.94														*			
Harrisburg, Pa	29–30			0.36														*			
Hartford, Conn	2			0.50														*			
Hatteras, N. C	13–14			0.40														.18			
Havre, Mont	24–26			0.88														*			
Helena, Mont	3–4			0.43														*			
Houghton, Mich	1			0.93														*			
Houston, Tex	2			1.02														.35			
Huron, S. Dak	1			0.95														*			
Independence, Cal	1–2			2.41														*			
Indianapolis, Ind	28–31			2.60														*			
Iola, Kans	20–21			1.82														*			
Jacksonville, Fla	13			0.42														.42			
Kalispell, Mont	3–4			0.61														*			
Kansas City, Mo	20–21	9:40 p. m.	4:45 a. m.	0.93	10:14 p. m.	10:30 p. m.	.04	.10	.30	.38	.42										
Keokuk, Iowa	20–21			1.43														*			
Key West, Fla	5	D. N. a. m.	D. N. a. m.	0.56	4:28 a. m.	4:42 a. m.	.04	.12	.39	.52											
Knoxville, Tenn	5–7			1.57														*			
La Crosse, Wis	26–27			0.85														*			
Lander, Wyo	27–28			0.91														*			
Lansing, Mich	11–12			0.87														*			
Lewiston, Idaho	24–25			0.52														*			
Lexington, Ky	28–29			1.13														*			
Lincoln, Nebr	25–27			0.76														*			
Little Rock, Ark	27–28			3.47														.54			
Los Angeles, Cal	16–18	1:05 p. m.	9:30 a. m.	5.74	3:17 a. m.	3:29 a. m.	2.13	.20	.42	.46											
Louisville, Ky	28–29			2.72														.50			
Ludington, Mich	26–27			1.03														*			
Lynchburg, Va	11			0.21														.16			
Macon, Ga	13			1.15														.49			
Madison, Wis	26–27			1.27														*			
Marquette, Mich	12–13			1.13														*			

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during January, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Memphis, Tenn.	30-31			1.73														0.50			
Meridian, Miss.	12	12:50 p.m.	2:05 p.m.	0.70	1:26 p.m.	1:54 p.m.	0.01	0.07	0.27	0.35	0.42	0.60	0.69								
	12	4:30 p.m.	9:30 p.m.	0.79	4:54 p.m.	5:04 p.m.	.01	.24	.38												
	21-22	8:40 p.m.	6:30 a.m.	2.07	8:58 p.m.	9:38 p.m.	.01	.28	.39	.45	.53	.59	.70	0.79	0.84						
Miami, Fla.	9	3:02 p.m.	3:55 p.m.	0.57	3:08 p.m.	3:25 p.m.	.01	.09	.30	.48	.52										
Milwaukee, Wis.	11-12			0.93														*			
Minneapolis, Minn.	28-29			0.74														*			
Mobile, Ala.	22	D. N. a.m.	8:28 a.m.	0.89	2:55 a.m.	3:31 a.m.	.01	.12	.26	.35	.39	.43	.49	.57	.59						
Modena, Utah	17-18			1.63														*			
	22	D. N. a.m.	10:40 a.m.	0.81	3:27 a.m.	3:44 a.m.	.05	.15	.26	.36	.40										
Montgomery, Ala.	31-Feb. 1	6:25 p.m.	D. N. a.m.	1.72	7:24 p.m.	7:43 p.m.	.37	.07	.35	.46	.54										
Moorhead, Minn.	28-29			0.52														*			
Mount Tamalpais, Cal.	13-14			1.75														.28			
Nantucket, Mass.	10			0.66														.15			
Nashvile, Tenn.	21-22	5:45 p.m.	7:35 a.m.	1.35	7:55 p.m.	8:24 p.m.	.03	.18	.32	.42	.49	.53	.59								
New Haven, Conn.	10-11			0.56														.19			
	12-13	6:18 p.m.	D. N. a.m.	1.02	6:20 p.m.	6:34 p.m.	.01	.30	.54	.64											
New Orleans, La.	21-22	11:20 p.m.	D. N. a.m.	1.51	12:29 a.m.	12:56 a.m.	.01	.11	.17	.53	.76	.95	1.00								
New York, N. Y.	12-13			0.35														*			
Norfolk, Va.	6-7			0.98														*			
Northfield, Vt.	2			0.29														*			
North Head, Wash.	20-23			1.75														*			
North Platte, Nebr.	25-26			0.33														*			
Oklahoma, Okla.	25-26			1.34														.58			
Omaha, Nebr.	25-27			0.86														*			
Oswego, N. Y.	12-13			0.76														*			
Palestine, Tex.	21	1:35 a.m.	11:28 a.m.	1.95	3:00 a.m.	3:23 a.m.	.03	.09	.34	.48	.53	.58									
Parkersburg, W. Va.	28-29			1.09														.34			
Pensacola, Fla.	22			0.66														.46			
Peoria, Ill.	11-12			1.72														*			
Philadelphia, Pa.	1-2			0.33														.10			
Phoenix, Ariz.	14-17			1.74														.15			
Pierre, S. Dak.	1			0.34														*			
Pittsburgh, Pa.	29-30			0.75														.16			
Pocatello, Idaho.	10-11			0.58														*			
Point Reyes Light, Cal.	2-3	9:30 a.m.	12:30 p.m.	2.39	7:42 p.m.	8:11 p.m.	.98	.20	.29	.34	.41	.46	.51								
Port Huron, Mich.	30-31			0.98														*			
Portland, Me.	10-11			0.91														.20			
Portland, Oreg.	20-23			1.84														.17			
Providence, R. I.	10			0.45														*			
Pueblo, Colo.	30			0.08														*			
Raleigh, N. C.	15-16			0.76														*			
Rapid City, S. Dak.	14-15			0.22														*			
Reading, Pa.	12-13			0.38														.21			
Red Bluff, Cal.	2			2.02														.28			
Reno, Nev.	2-3			2.50														*			
Richmond, Va.	7			0.70														*			
Rochester, N. Y.	1-2			0.82														*			
Roseburg, Oreg.	7-9			2.05														*			
Roswell, N. Mex.	20			0.38														.17			
Sacramento, Cal.	2-3			3.41														.40			
Saginaw, Mich.	12-13			0.66														*			
St. Joseph, Mo.	20			0.86														*			
St. Louis, Mo.	10-12			3.75														*			
St. Paul, Minn.	28-29			0.61														*			
Salt Lake City, Utah	27-29			0.59														*			
San Antonio, Tex.	20-21	9:15 p.m.	4:00 a.m.	1.12	12:04 a.m.	12:40 a.m.	.06	.23	.28	.43	.45	.49	.65	.88	.92						
San Diego, Cal.	15-18			2.90														*			
Sand Key, Fla.	9-10	4:43 p.m.	12:23 a.m.	0.66	11:02 p.m.	11:29 p.m.	.04	.06	.12	.23	.34	.46	.50								
Sandusky, Ohio	12			0.91														*			
San Francisco, Cal.	2-3			3.67														*			
San Jose, Cal.	3			2.31														.39			
San Luis Obispo, Cal.	16-17			3.39														.58			
Santa Fe, N. Mex.	15-19			1.38														*			
Sault Ste. Marie, Mich.	27			0.66														*			
Savannah, Ga.	16-17			0.71														.20			
Scranton, Pa.	16			0.46														*			
Seattle, Wash.	21-22			2.34														.25			
Sheridan, Wyo.	27-28			0.57														*			
Shreveport, La.	27-28			2.65														.52			
Sioux City, Iowa	28-29			0.54														*			
Spokane, Wash.	3			0.38														*			
Springfield, Ill.	11-12			1.86														*			
Springfield, Mo.	11-12			2.71														.49			
Syracuse, N. Y.	1-2			1.00														*			
Tacoma, Wash.	20-23			2.00														.12			
Tampa, Fla.	17			0.12														.12			
Tatoosh Island, Wash.	21-23			3.34														.22			
Taylor, Tex.	20-21	2:28 p.m.	7:28 a.m.	1.31	2:01 a.m.	2:16 a.m.	.23	.25	.45	.54	.58										
Terre Haute, Ind.	28-31			4.49														.51			
Thomasville, Ga.	7			0.49														.48			
Toledo, Ohio	30-31			1.29														.39			
Tonopah, Nev.	18			0.65														*			
Topeka, Kans.	20-21			0.92														.28			
Valentine, Nebr.	1			0.36														*			
Vicksburg, Miss.	12	9:25 a.m.	10:05 a.m.	0.61	9:41 a.m.	9:52 a.m.	.05	.24	.45	.51											
	27	7:15 a.m.	1:50 p.m.	1.12	8:29 a.m.	8:54 a.m.	.05	.10	.18	.30	.42	.48									
Walla Walla, Wash.	22-24			0.94														*			
Washington, D. C.	29-30			0.59														.10			
Wichita, Kans.	25-26			0.91														*			
Williston, N. Dak.	28			0.34														*			
Wilmington, N. C.	22			0.22														.20			
Winnemucca, Nev.	8			0.59														*			
Wytheville, Va.	6-7			1.98														*			
Yankton, S. Dak.	11-12			0.43														*			
Yellowstone Park, Wyo.	3-4			0.80														*			

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, January, 1916.*

Stations.	Altitude above M. S. L.* (Jan. 1, 1916.)	Pressure.			Temperature.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea-level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	Inches.	Inches.	Inches.	°F.	°F.	°F.	°F.	°F.	°F.	Inches.	Inches.	Inches.
St. Johns, N. F.	125	29.58	29.72	−0.14	21.8	− 2.0	27.6	15.9	46	4	2.91	−3.00	16.0
Sydney, C. B. I.	48	29.94	*29.98*	+ *.03*	23.8	+ 3.3	31.8	15.9	46	− 3	1.62	−3.48	12.0
Halifax, N. S.	88	29.97	*30 08*	+ *.11*	23.8	+ 2.0	33.0	14.6	55	− 5	2.87	−2.90	14.9
Yarmouth, N. S.	65	30.02	30.09	+ .09	26.8	+ 0.5	33.3	20.3	45	5	2.90	−2.51	21.3
Charlottetown, P. E. I.	38	29.99	30.03	+ .07	19.2	+ 2.2	26.2	12.1	41	− 8	2.67	−1.29	19.4
Chatham, N. B.	28	30.04	*30.07*	+ *.10*	15.0	+ 5.2	25.4	4.5	49	−14	2.47	−1.12	16.7
Father Point, Que.	20	30.04	30.07	+ .09	13.4	+ 5.4	22.0	4.9	43	−12	2.02	−0.83	17.0
Quebec, Que.	296	29.77	30.11	+ .09	12.4	+ 3.3	21.4	3.5	44	−18	4.45	+0.44	29.3
Montreal, Que.	187	29.89	30.11	+ .07	19.1	+ 7.4	27.4	10.8	45	− 9	4.15	+0.42	17.7
Stonecliffe, Ont.	489	29.45	*30.08*	+ *.06*	13.8	+ 7.4	26.5	1.2	44	−25	3.53	+1.21	26.7
Ottawa, Ont.	236	29.84	*30.19*	+ *.16*	17.6	+ 8.0	27.3	7.9	44	−16	3.97	+0.98	15.0
Kingston, Ont.	285	29.81	30.14	+ .09	25.6	+ 8.5	33.1	18.2	44	− 7	3.87	+0.42	9.7
Toronto, Ont.	379	29.69	*30.09*	+ *.04*	30.1	+ 8.7	37.1	23.0	53	1	2.50	−0.42	3.1
White River, Ont.	1,244	28.62	*30.01*	*.00*	3.0	+ 0.7	16.8	−10.9	39	−51	4.50	+2.81	45.0
Port Stanley, Ont.	592	29.48	30.14	+ .07	29.0	+ 6.8	35.8	22.2	48	− 2	5.56	+2.57	6.2
Southampton, Ont.	656	29.34	*30.07*	+ *.04*	27.8	+ 7.4	35.4	20.3	59	1	5.25	+1.20	15.1
Parry Sound, Ont.	688	29.33	30.06	+ .05	22.4	+ 9.6	31.5	13.3	46	−15	6.10	+2.02	42.8
Port Arthur, Ont.	644	29.32	30.07	.00	6.6	+ 3.5	17.5	− 4.4	37	−27	1.95	+1.13	19.5
Winnipeg, Man.	760	29.28	30.18	+ .07	− 6.8	0.0	1.8	−15.4	22	−41	3.36	+2.48	33.6
Minnedosa, Man.	1,690	28.20	30.16	+ .06	− 9.6	− 2.4	− 0.9	−18.6	20	−40	1.18	+0.38	11.8
Qu'Appelle, Sask.	2,115	27.72	30.17	+ .09	−12.9	− 9.1	− 4.6	−21.2	20	−46	1.10	+0.60	11.0
Medicine Hat, Alberta	2,144	27.77	*30.24*	+ *.17*	−11.5	−17.0	− 2.0	−21.0	30	−48	0.53	−0.04	5.3
Swift Current, Sask.	2,392	27.41	*30.21*	+ *.12*	−12.6	−15.7	− 3.4	−21.9	27	−49	2.70	+2.06	27.0
Calgary, Alberta	3,428	26.40	*30.25*	+ *.22*	− 7.8	−16.2	1.7	−17.2	36	−41	0.79	+0.26	7.9
Banff, Alberta	4,521	25.22	*30.23*	+ *.23*	−13.1	−25.2	− 1.0	−25.2	19	−46	2.85	+1.66	28.5
Edmonton, Alberta	2,150	27.77	*30.26*	+ *.23*	−12.6	−14.4	− 3.5	−21.6	29	−45	1.09	+0.41	10.9
Prince Albert, Sask.	1,450	28.50	*30.20*	+ *.11*	−15.0	− 6.6	− 6.9	−23.1	17	−58	0.96	−0.01	9.6
Battleford, Sask.	1,592	28.37	*30.27*	+ *.19*	−15.6	− 9.7	− 7.0	−24.1	20	−61	0.76	+0.36	7.6
Kamloops, B. C.	1,262	28.83	30.23	+ .27	− 3.0	−26.0	3.3	− 9.5	32	−28	0.65	−0.17	6.5
Victoria, B. C.	230	29.59	29.85	− .12	29.5	− 9.0	33.8	25.2	48	15	4.21	−1.18	30.2
Barkerville, B. C.	4,180	25.51	30.08	+ .19	− 9.0	−26.8	− 1.5	−16.4	21	−40	1.40	−1.20	14.0
Hamilton, Bermuda	151	30.16	30.33	+ .20	60.0	− 2.0	65.9	54.1	71	46	1.70	−3.24	....

*The altitudes given above were furnished by the Director of the Canadian Meteorological Service, March 9, 1916, and refer to cisterns of barometers at the respective stations. Where sea-level pressures and departures are *omitted* new reduction factors are in course of computation.—C. A., jr.

Chart I. Hydrographs of Several Principal Rivers, January, 1916.

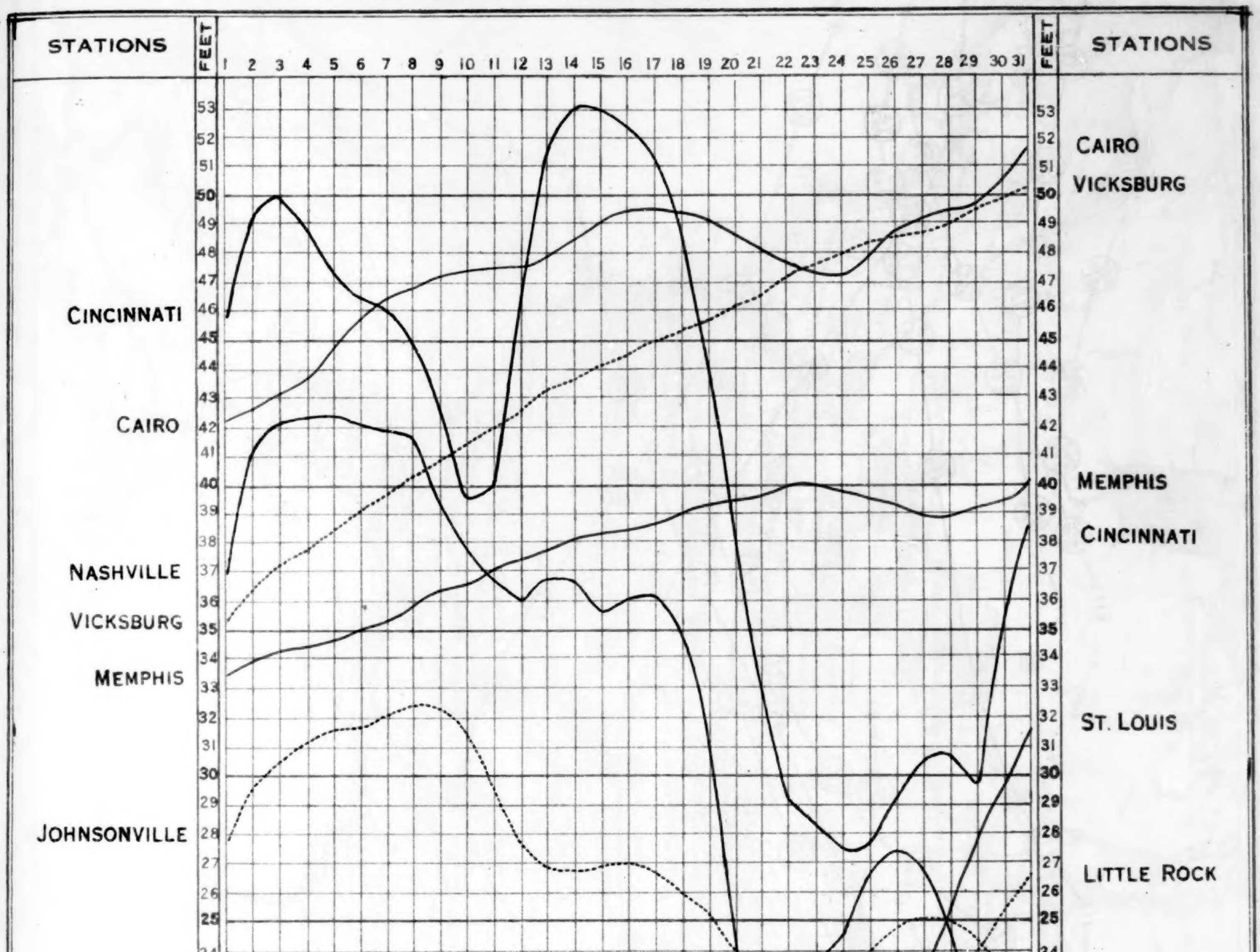

Chart II. Tracks of Centers of High Areas, January, 1916.

(Plotted by R. H. Weightman.)

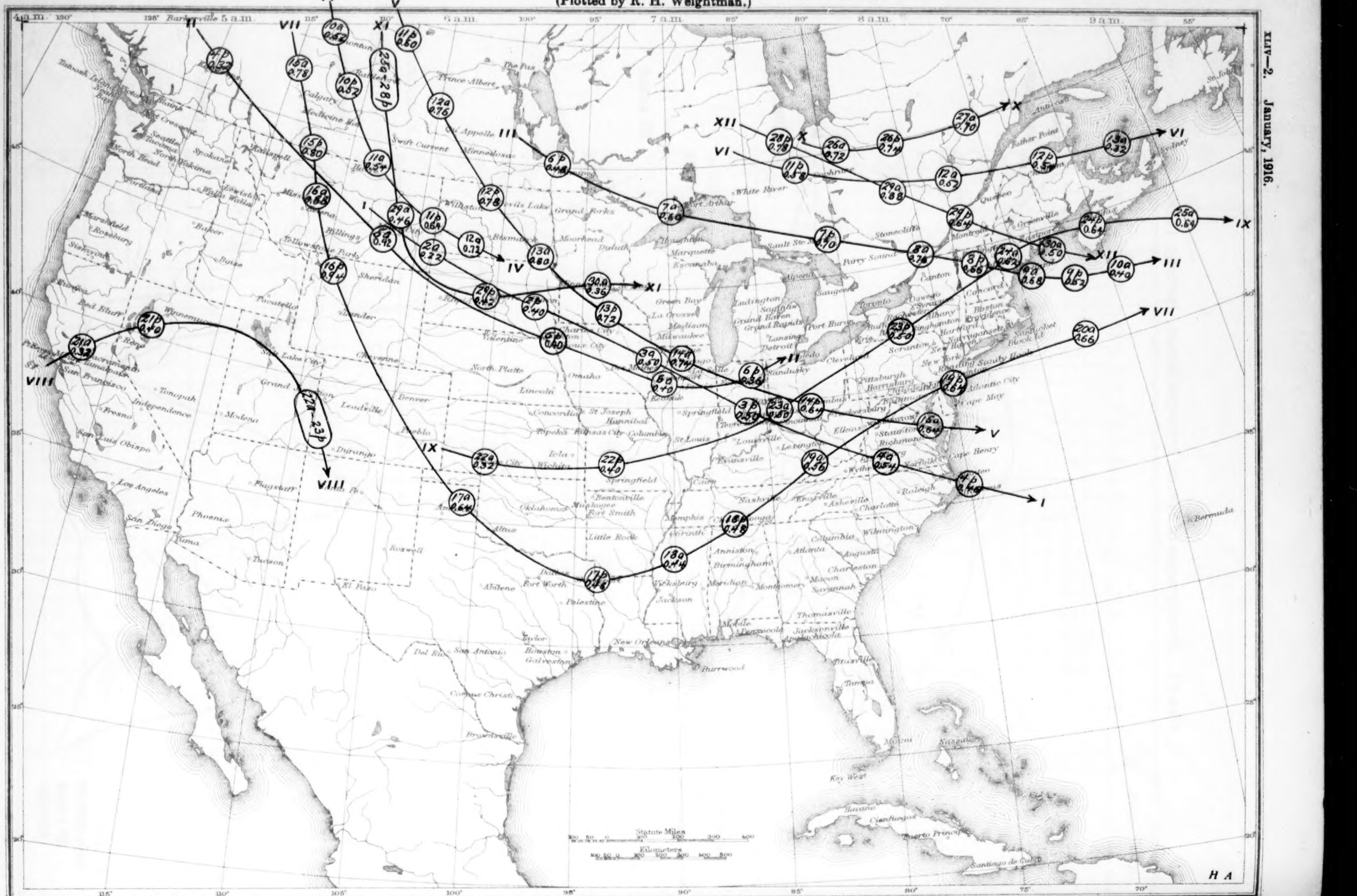

Chart III. Tracks of Centers of Low Areas, January, 1916.

(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, January, 1916.
(Plotted by R. H. Weightman.)

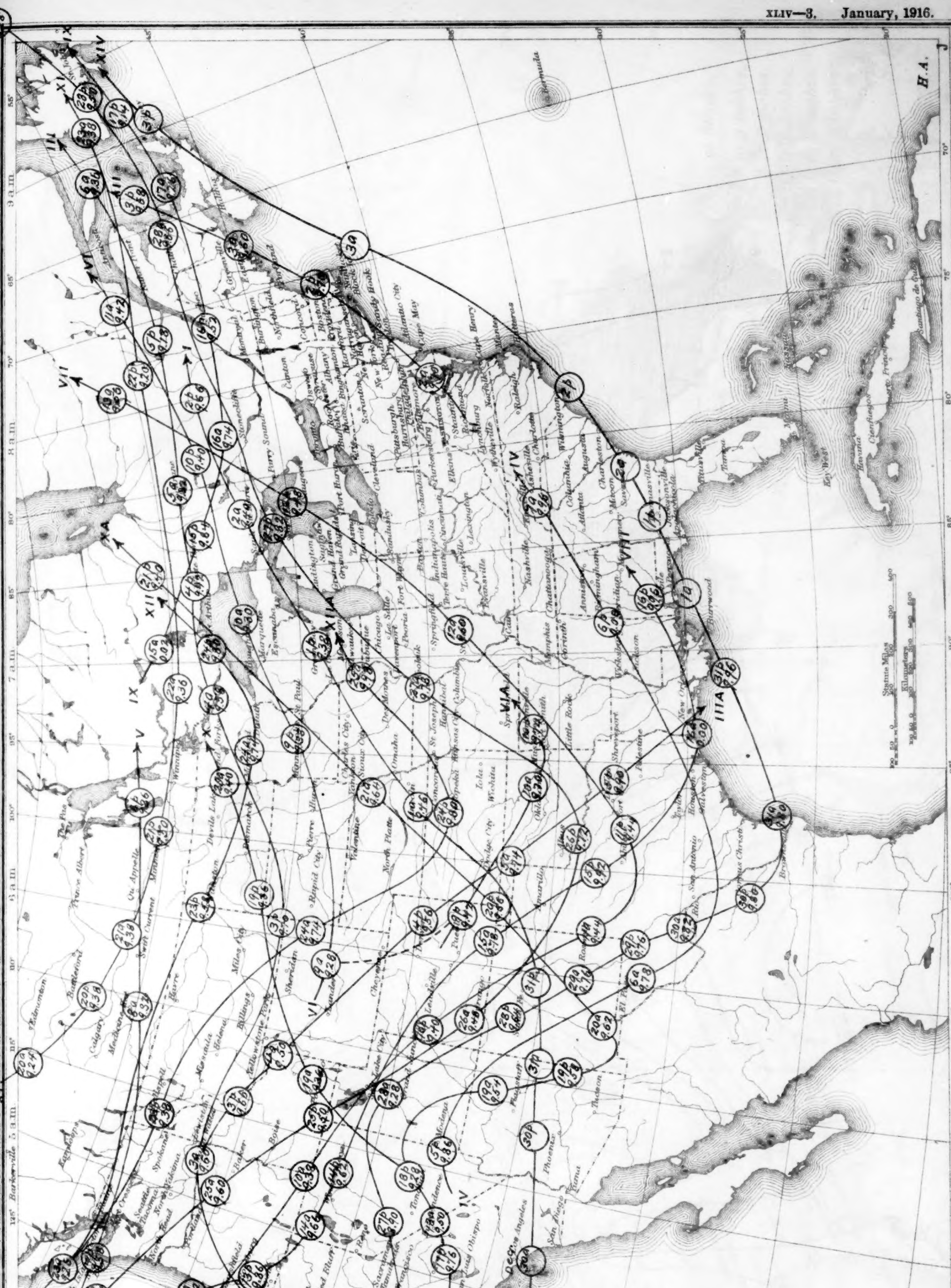

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, January, 1916.

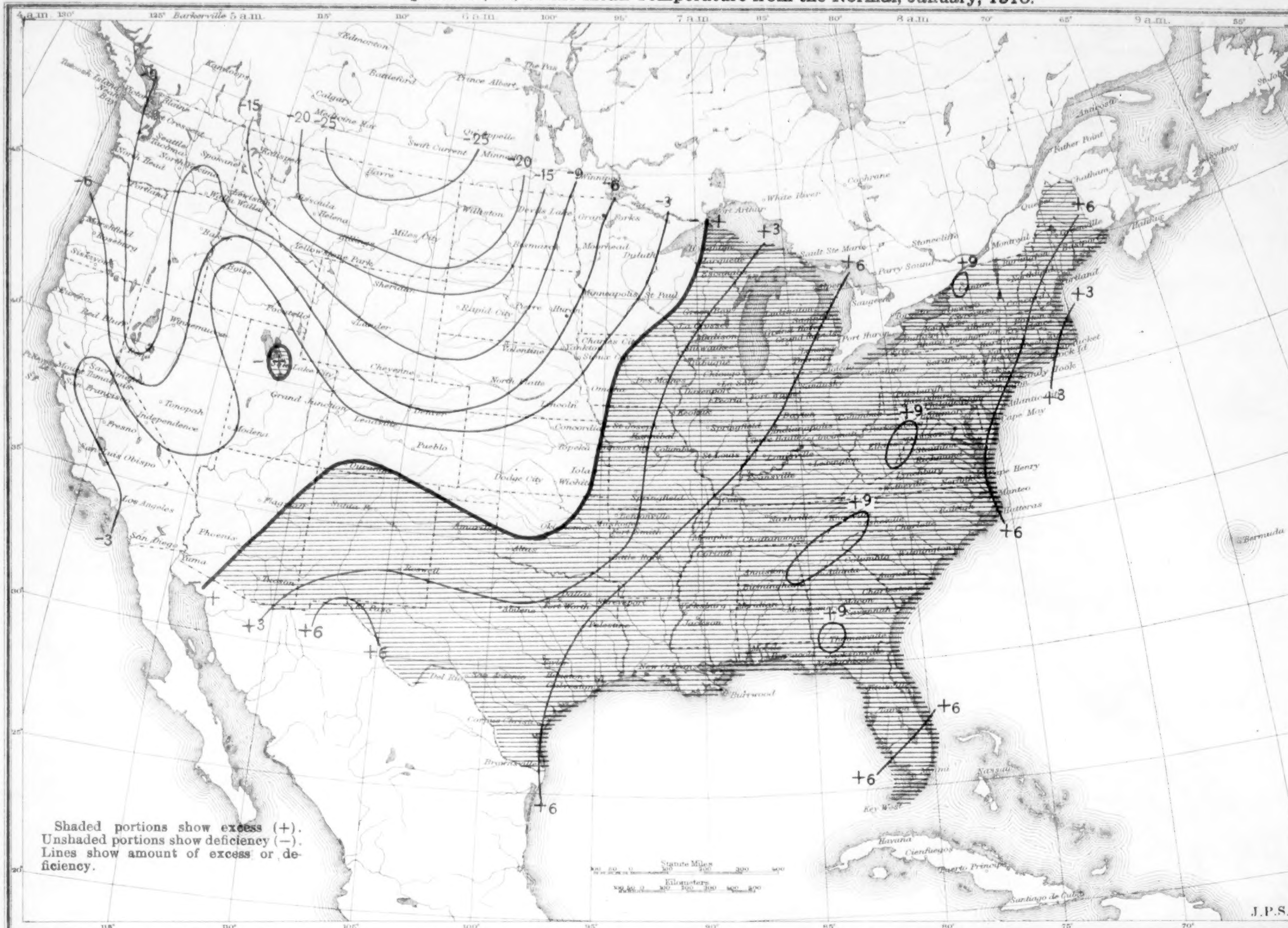

Chart V. Total Precipitation, January, 1916.

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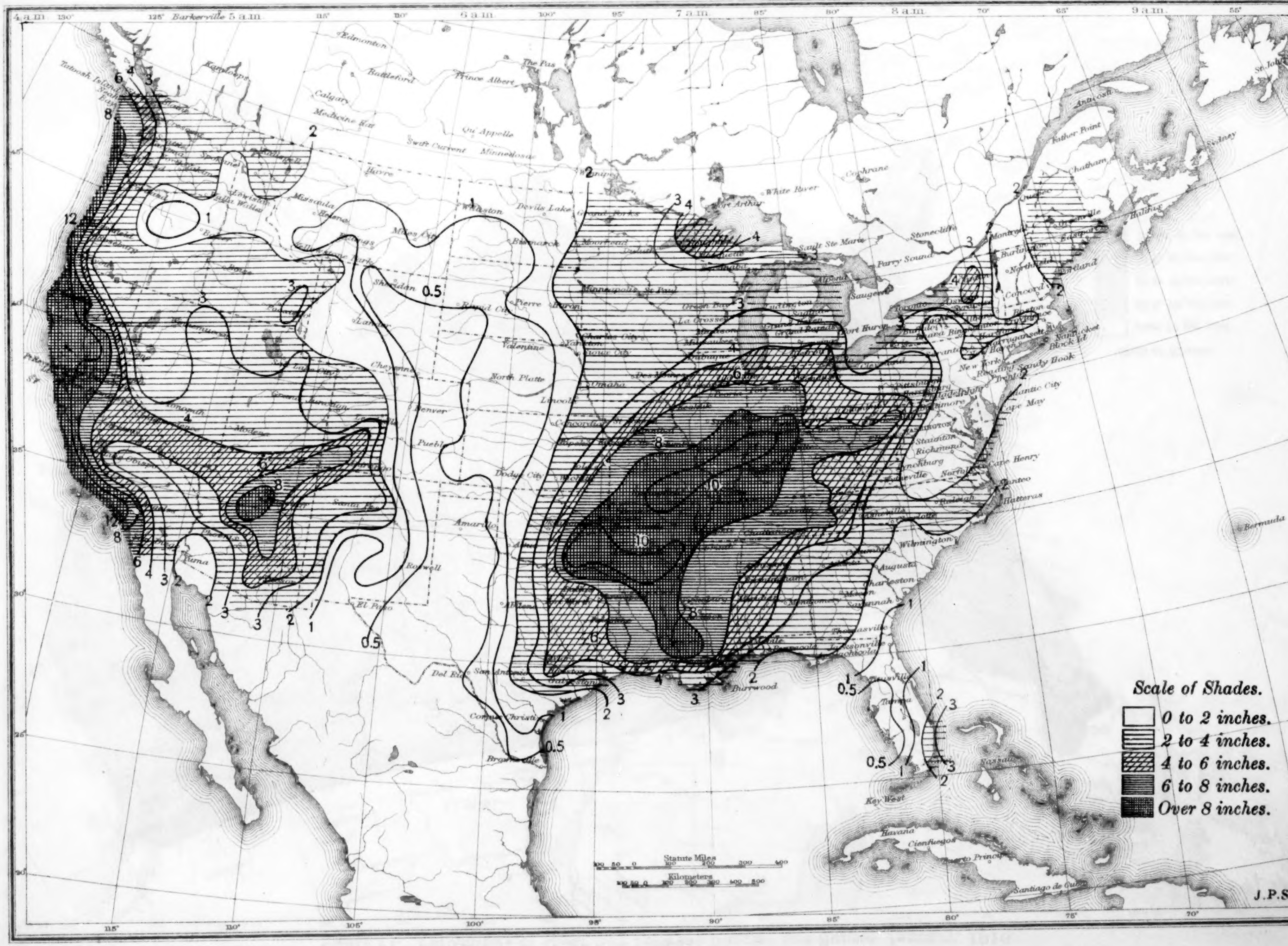

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, January, 1916.

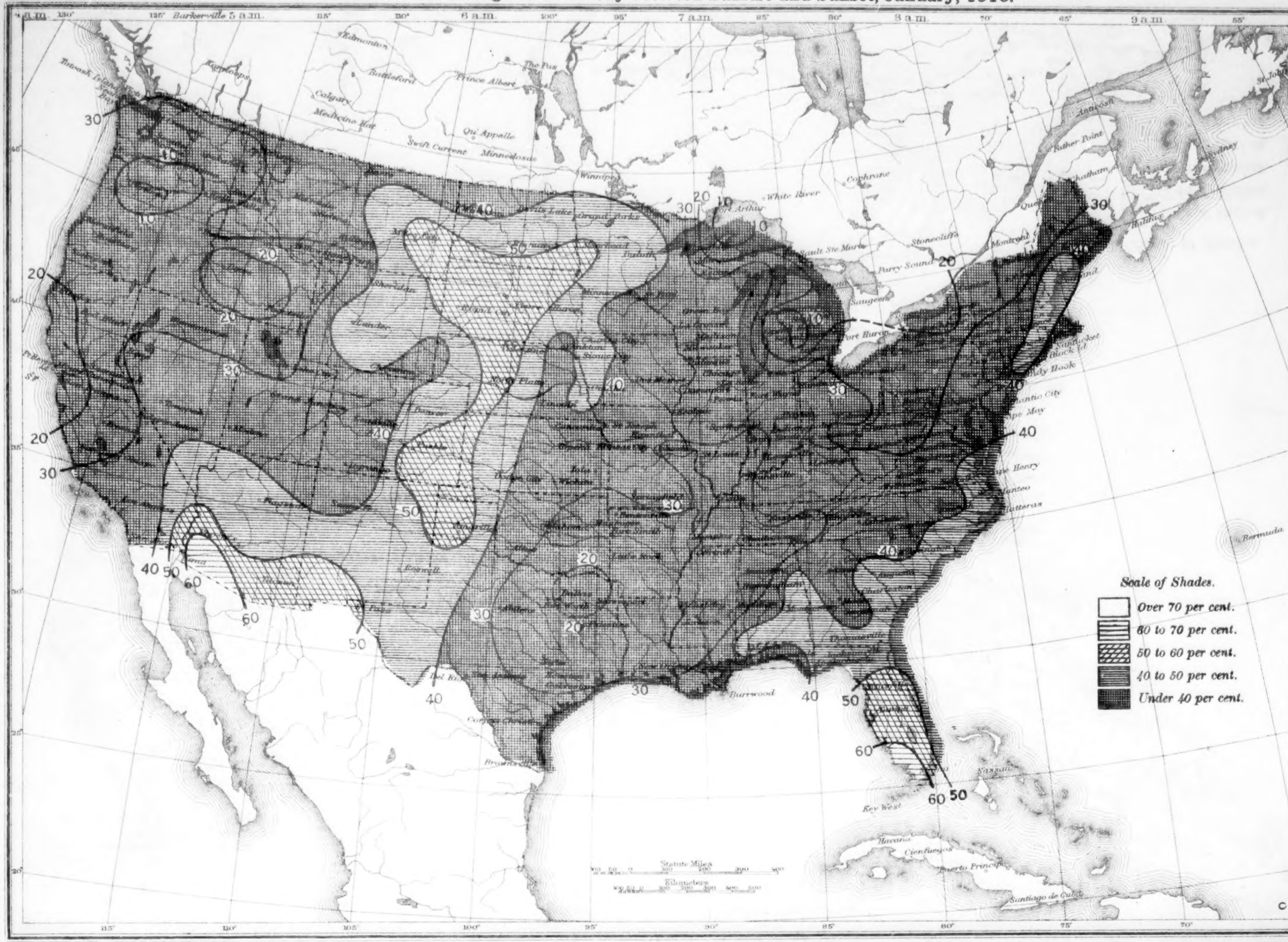

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, January, 1916.

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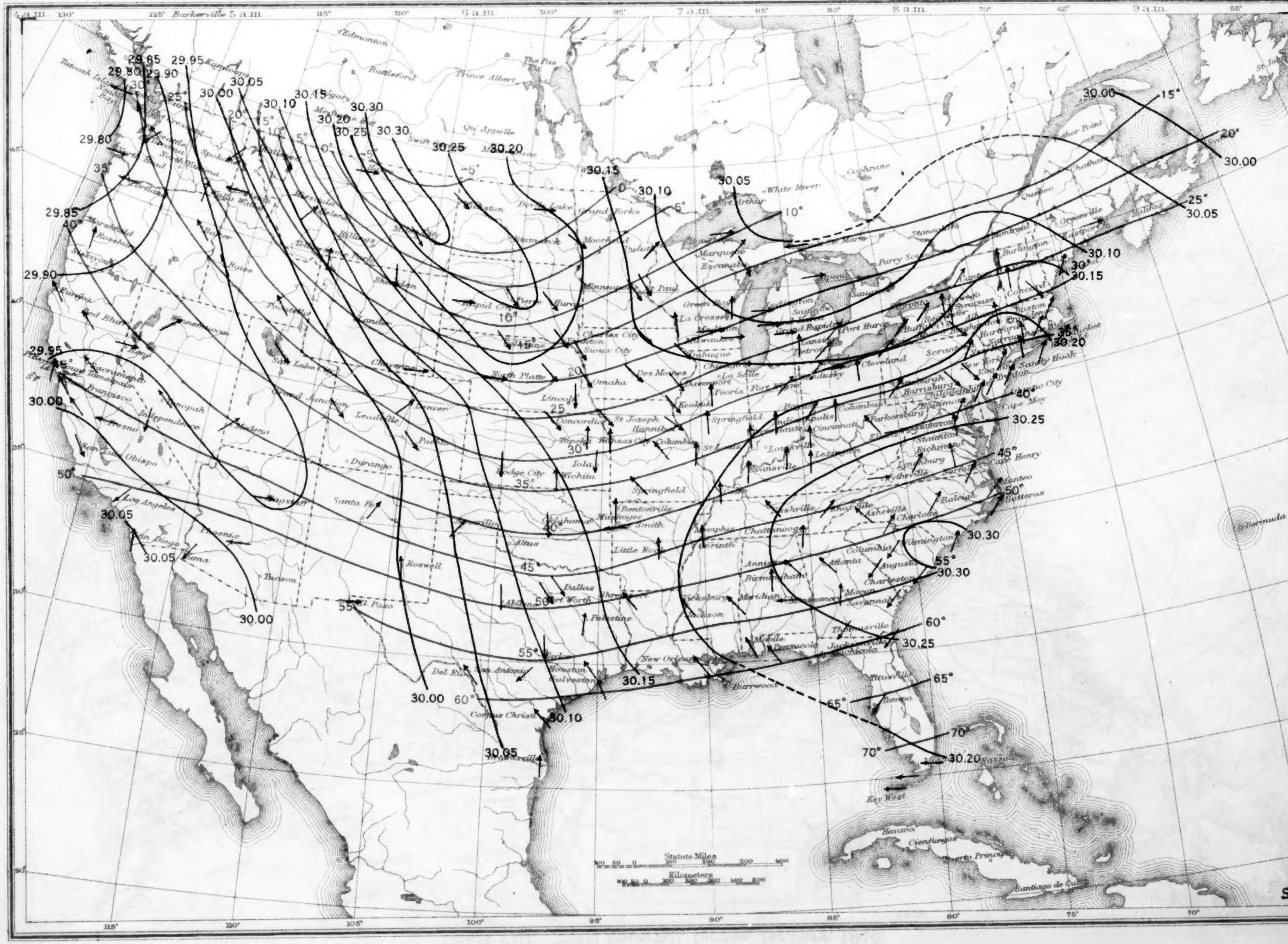

Chart VIII. Total Snowfall, Inches, January, 1916.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, January, 1915.
(Plotted by F. A. Young.)

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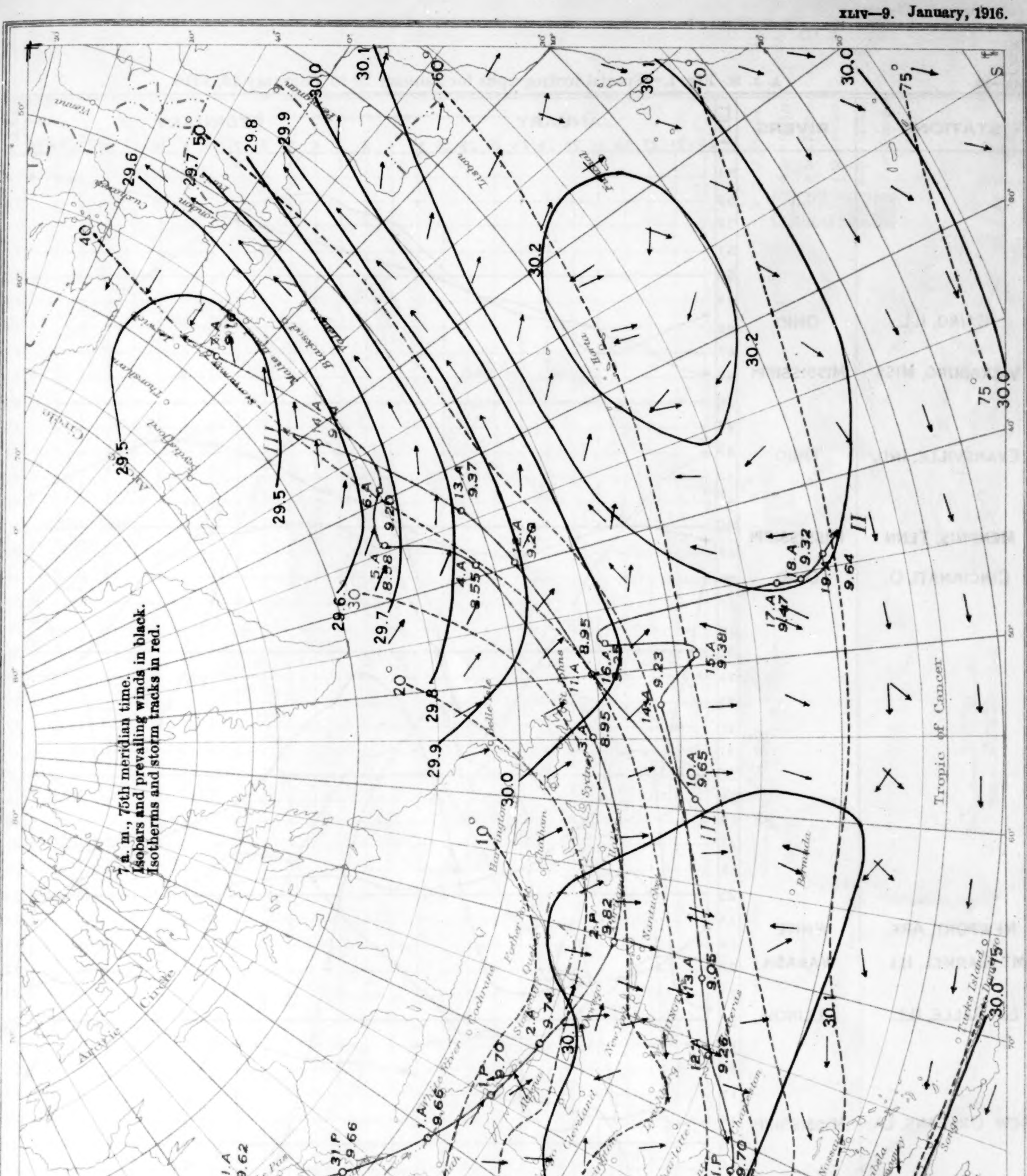
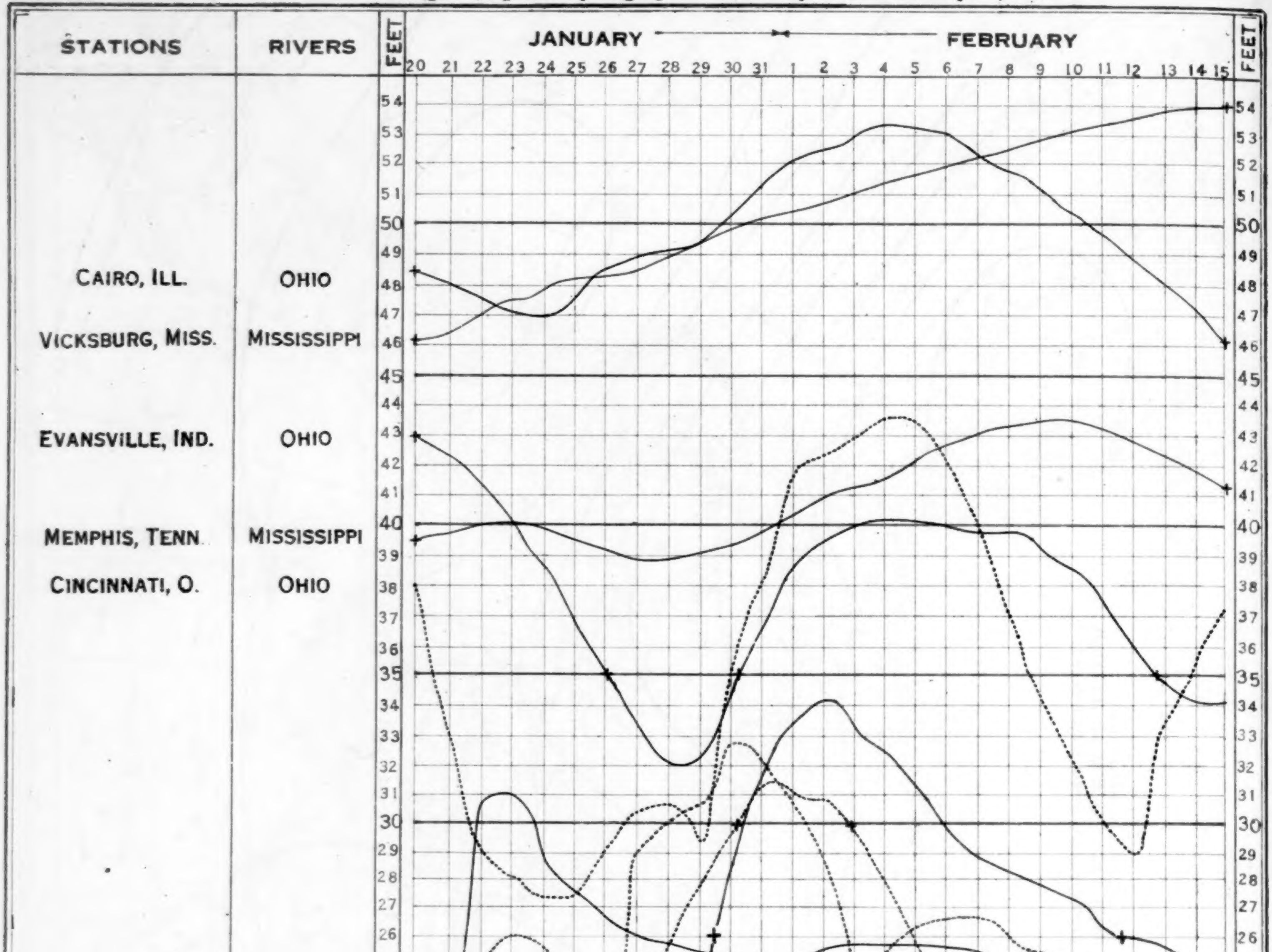
(Plotted by F. A. Young.)



A. J. H. Fig. 1.—Special hydrographs for January 20 to February 15, 1916.



A. J. H. Fig. 2.—Precipitation in the six days, January 26–31, 1916.

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